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Scene on a banana laden steamer at the Galveston docks.

Unloading Bananas by Machinery

New Methods of Handling Delicate Fruit Rapidly and Without Injury

The city of Galveston is a port where many shiploads of bananas are received to be unloaded and sent by trainloads to western and southwestern cities, as the banana is eaten as generally as the apple or peach. Fruits are generally delicate merchandise that require careful handling, and this is particularly the case with bananas, which cannot be conveniently packed, and which, in this country, have such a long journey, with many transfers, before reaching their market.

The unloading of this fruit at Galveston is performed by an ingenious mechanism operated by electricity. Ranged along the fruit wharf are a number of odd looking, pyramidal houses, each with a sort of an elephant trunk protruding from their sides. These are the electrically operated fruit conveyors. As soon as the ship is laid alongside, the trunk swings out and drops a long conveyor belt down through the hatches into the hold. Then the wheels begin to turn and the canvas pockets travel in an endless succession from the hold to the wharf.

Down in the hold the men lay the bunches of bananas onto the conveyor, placing a single bunch in each pocket as it presents itself. As the bunches reach the wharf end they are taken by men who hurry them off to the various railroad cars on nearby tracks. The wharf appears then to be swarming with moving bunches of bananas set on two legs.

An expert freight classifier inspects each bunch as it is carried away. "Number nine!" calls the expert, and the man under the bunch moves to the open door of a car from which a flag displaying the figure "9" is hung. This grade is the highest in bananas, and only the best bunches of the firmest, most mature fruit are so classified; yet most of the bunches brought into this port are of that quality. There are also "eights" and "sevens," these being smaller and riper fruit. As the classifier calls "yellow flag," the toter carries the bunch to a car where riper bananas are loaded, mounting improvised steps and passing his bunch up to the men inside, where it is neatly stacked on the bottom of the car to be shipped to some nearby market where the fruit can be disposed of quickly.

Before this mechanical carrier was put to work it was customary to have a long line of men stationed at arm's length apart, extending from the depths of the hold of the vessel to the freight cars on the dock, who carefully passed the bunches of fruit from hand to hand in endless succession, thus necessitating a large number of men and resulting in many handlings.

There are as many varieties of bananas as there are of apples, and they are both red and yellow in color. At one time it was customary to call the yellow variety plantains, and the red fruit bananas, but authorities agree that there is no specific difference between plantains and bananas. The yellow variety is the kind imported into the United States most frequently, and in the greatest quantities, although in some localities the red fruit is preferred. Most of the latter are the *baracoa*, or Red Jamaica, while one of the best of the large yellow variety is the Martinique.

A Record of Achievement—I*

The Contribution of the Chemist to the Industrial Development of the United States

By Bernhard C. Hesse

THE CHEMIST AND HIS WORK.

The American public has seemingly given too little consideration to those industries of this country that make use of chemical knowledge and experience in the manufacture or utilization of products and yet these are the ones that compose chemical industry or industrial chemistry.

The substitution of accurate, dependable, and nonfailing methods of operation for "rule of thumb" and "helter skelter" methods must appeal to every manufacturer as a decided advancement and a valuable contribution.

The chemist has made the wine industry reasonably independent of climatic conditions; he has enabled it to produce substantially the same wine, year in and year out, no matter what the weather; he has reduced the spoilage from 25 per cent to 0.46 per cent of the total; he has increased the shipping radius of the goods and has made preservatives unnecessary.

In the copper industry he has learned and taught how to make operations so constant and so continuous that in the manufacture of blister copper valuations are less than $1 apart on every $10,000 worth of product, and in refined copper the valuations of the product do not differ by more than $1 in every $50,000 worth of product. The quality of output is maintained constant within microscopic differences.

Without the chemist the corn products industry would never have arisen, and in 1914 this industry consumed as much corn as was grown in that year by the nine States of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, and Delaware combined; this amount is equal to the entire production of the State of North Carolina and about 80 per cent of the production of each of the States of Georgia, Michigan, and Wisconsin; the chemist has produced over one hundred useful commercial products from corn, which, without him, would never have been produced.

In the asphalt industry the chemist has taught how to lay a road surface that will always be good, and he has learned and taught how to construct a suitable road surface for different conditions of service.

In the cottonseed oil industry, the chemist standardized methods of production, reduced losses, increased yields, made new use of wastes and by-products, and has added somewhere between $10 and $12 to the value of each bale of cotton grown.

In the cement industry, the chemist has ascertained new ingredients, has utilized theretofore waste products for this purpose, has reduced the waste heaps of many industries and made them his starting material; he has standardized methods of manufacture, introduced methods of chemical control, and has insured constancy and permanency of quality and quantity of output.

In the sugar industry, the chemist has been active for so long a time that "the memory of man runneth not to the contrary." The sugar industry without the chemist is unthinkable.

The Welsbach mantle is distinctly a chemist's invention, and its successful and economical manufacture depends largely upon chemical methods. It would be difficult to give a just estimate of the economic effect of this device upon illumination, so great and valuable is it.

In the textile industry, he has substituted uniform, rational, well thought-out and simple methods of treatment of all the various textile fabrics and fibers where mystery, empiricism, "rule of thumb" and their accompanying uncertainties reigned.

In the fertilizer industry, it was the chemist who learned and who taught how to make our immense beds of phosphate rock useful and serviceable to man in the enrichment of the soil; he has taught how to make waste products of other industries useful and available for fertilization, and he has taught how to make the gas works contribute to the fertility of the soil.

In the soda industry, the chemist can successfully claim that he founded it, developed it, and brought it to its present state of perfection and utility, but not without the help of other technical men; the fundamental ideas were and are chemical.

In the leather industry, the chemist has given us all of the modern methods of mineral tanning, and without them the modern leather industry is unthinkable. In the case of vegetable-tanned leather he has also stepped in, standardized the quality of incoming material and of outgoing product.

In the flour industry, the chemist has learned and taught how to select the proper grain for specific purposes, to standardize the product, and how to make flour available for certain specific culinary and food purposes.

In the brewing industry, the chemist has standardized the methods of determining the quality of incoming material and of outgoing products, and has assisted in the development of a product of a quality far beyond that obtaining prior to his entry into that industry.

In the preservation of foods, the chemist made the fundamental discoveries; up to twenty years ago, however, he took little or no part in the commercial operations, but now is almost indispensable to commercial success.

In the water supply of cities, the chemist has put certainty in the place of uncertainty; he has learned and has shown how, by chemical methods of treatment and control, raw water of varying quality can be made to yield potable water of substantially uniform composition and quality.

The celluloid industry and the nitro-cellulose industry owe their very existence and much of their development to the chemist.

In the glass industry, the chemist has learned and taught how to prepare glasses suitable for the widest range of uses and to control the quality and the quantity of the output.

In the pulp and paper industry, the chemist made the fundamental observations, inventions and operations, and to-day he is in control of all the operations of the plant itself; to the chemist also is due the cheap production of many of the materials entering into this industry as well as the increased and expanding market for the product iself.

THE STATISTICAL POSITION.

For the census year of 1909 the wage-earners and the value of manufactured products and the value added by manufacture in twelve of these industries and in the manufacture of chemicals is given in Table I*a*.

Table I*a*	Wage-earners	Product value	Value added by manufacture
Wine	1,911	$ 13,120,846	$ 6,495,313
Copper	15,628	378,805,974	45,274,336
Fertilizer	18,310	103,960,213	34,438,293
Textiles	44,046	83,556,432	48,295,131
Canned and preserved foods	59,968	157,101,201	55,278,142
Cotton-seed oil	17,071	147,867,894	28,034,419
Cement	26,775	63,205,455	33,861,664
Sugar	20,730	327,371,780	52,523,806
Brewing	54,579	374,730,096	278,134,460
Leather	62,202	327,874,187	79,395,254
Glass	68,911	92,095,203	59,975,704
Paper and wood pulp	75,978	267,656,964	102,214,623
Chemicals (strictly)	23,714	117,688,887	53,567,351
TOTALS	529,823	$2,455,035,132	$897,688,496
Table I*b*			
Iron and steel	278,505	$1,377,151,817	$399,013,072
Petroleum refining	13,929	236,997,659	37,724,257
Lead smelting and refining	7,424	167,405,650	15,442,628
Illuminating and heating gas	37,215	166,814,371	114,386,257
Confectionery	44,638	134,795,913	53,645,140
Paint and varnish	14,240	124,889,422	45,873,867
Soap	12,999	111,357,777	39,178,359
Carpets and rugs	33,307	71,188,152	31,625,148
Explosives	6,274	40,139,061	17,328,113
Zinc smelting and refining	6,655	34,205,894	8,975,893
Turpentine and rosin	39,511	25,295,017	20,384,174
Oil cloth and linoleum	5,201	23,339,022	7,788,921
Chocolate and cocoa	2,826	22,390,222	8,867,162
Baking powder and yeast	2,155	20,774,588	11,436,603
Dyestuffs and extracts	2,397	15,954,574	6,270,923
Blacking, cleansing and polishing preparations	2,417	14,679,120	7,716,728
Wood distillation other than turpentine	2,721	9,736,998	3,861,147
Oleomargarine	606	8,147,629	1,650,997
TOTALS	513,020	$2,605,262,886	$829,052,389
TOTAL FOR 31 CHEMICAL INDUSTRIES	1,042,843	$5,060,298,015	$1,726,740,885
TOTAL FOR ALL INDUSTRIES	6,615,046	$20,672,051,870	$8,529,260,992

AMERICAN INDUSTRIES VS. COAL-TAR DYES.

A most liberal estimate of the market value of the world's entire production of coal-tar dyes places it under $100,000,000; the entire consumption in the United States is less than $15,000,000, duty included, and this amounts to about 15 cents per person per year.

Now, which would you rather have, these thirteen industries with their $2,500,000,000 worth of manufactured product or the coal-tar industry with its $100,000,000 worth of product? The number of persons employed in these above thirteen industries is in excess of 500,000; the entire world's supply of coal-tar dyes is made by fewer than 40,000 people. Which would you rather have?

These thirteen industries employ 8 per cent of all wage-earners in manufacturing enterprises in the United States, produce 12 per cent of the total value of manufactured product, and 10.5 per cent of the total value added by manufacture. In other words, the chemist engaged in these thirteen pursuits plays an important, if not indispensable, part in the lives of 8 per cent of our wage-earners, and affects 12 per cent of our manufacture-values and 10.5 per cent of our values added by manufacture. But the total number of chemists makes up only about 0.01 per cent of the population of the United States.

NO NATION CAN DO EVERYTHING ITSELF.

Of course, it may be said that having made all these other things, there is no excuse why the American should not make coal-tar dyes in addition. Perhaps so; but nations, like individuals, cannot each have or do everything. If each nation could do everything equally as well as every other nation, there would be no occasion whatever for international business. As this world is constituted, each nation does that which it can do the best and trades off the product for what some other nation can do better than it, and both sides are satisfied and make a profit; this is the same as the relationship between individuals. The shoemaker can make shoes better than he can bake bread; he makes shoes and exchanges part of his income with the baker for bread which the baker has made.

If American chemists can operate these industries better than or as good as other nations, it is no real ground for criticism that they cannot do everything better than any other nation, no more than the shoemaker is to be criticised because he cannot make as good a suit of clothes as the tailor. If you want the shoemaker to be able to make a suit of clothes as well as the tailor you must provide him with the opportunity to learn how to tailor and take care of him while he is learning, and no doubt his suit of clothes will cost him more than it would cost an established tailor to turn out the same kind of a suit of clothes, and you must again help your shoemaker while he is trying to market his suit of clothes against the established tailor.

EIGHTEEN ADDITIONAL AMERICAN CHEMICAL INDUSTRIES.

The above nineteen American industries referred to by no means comprise all the American industries in which the chemist can be of help and assistance. Many more are open.

A search through the census for 1909 discloses the eighteen additional industries listed in Table I*b* which make use of chemists in the control of their operations.

In these eighteen additional industries the chemist affects 8 per cent of our wage-earners, 12.6 per cent of our manufacture values, and 9.7 per cent of our values added by manufacture. For these thirty-seven industries, then, the 0.01 per cent of chemists of our population directly affect 16 per cent of our wage-earners, 24.6 per cent of our manufacture values, and 20.2 per cent of our values added by manufacture.

This, therefore, is a measure of the influence of the chemist upon the industrial development of the United States; however gratifying this result is, it is nevertheless true that many other industries could employ chemical control to great advantage, if they only would, and many establishments under the above cited industries could, if they would, make use of chemical control. There is plenty of work left for the chemist to do in these industries to keep him fully and profitably engaged. This being so, why should he not continue to direct his energies to improving those things that he already can do, rather than attempt new and exotic things which others can do better than he?

THE FOREIGN BUSINESS.

So much for our internal relations. How about our international relations? To answer this question I will use the official classification of the German government as to what constitutes products of and for chemical industry and also the same government's corresponding figures for 1913.

No two countries, speaking through their statistical departments, have the same working definition of chemical industry. None of the official classifications is as comprehensive as is the official German classification. So far as the exchange of products and commodities involved in chemical pursuits is concerned, the German classification shows a total of 442 items, of which 229 are involved in international trade between Germany and the United States. According to these figures and this classification, the United States imported from German in 1913, $60,860,880, and exported to Germany $156,036,090, or a total business of $216,896,970, with a balance in favor of the United States of $95,175,210. I have selected from this 1913 list of items of business between Germany and this country those whose gross is $400,000 per annum or over (Table II).

It is interesting to note that we sell Germany more lard than Germany sells us of potash and aniline and other coal-tar dyes put together; that we sell Germany

* An address before the American Chemical Society at its fiftieth meeting, New Orleans, March 31st-April 3rd, 1915. From *The Journal of Industrial and Engineering Chemistry*.

half again as much refined petroleum as it sells us aniline and other coal-tar dyes; that we sell Germany practically the same amount of pig and scrap lead as Germany sells us of alizarin and anthracene dyes; that we sell Germany almost as much paraffine as Germany sells us of indigo; and so on through the list.

TABLE II—U. S. CHEMICAL TRADE WITH GERMANY (1913)

U. S. imports from Germany	Value in U. S. money	U. S. exports to Germany
	$75,000,000	1 Copper
	26,700,000	2 Lard
1 Potash salts	18,819,000	
	12,690,000	3 Refined petroleum
2 Aniline and other coal-tar dyes	7,290,000	
	4,970,000	4 Phosphate rock
	4,880,000	5 Oleomargarine
	4,585,000	6 Turpentine rosin
	4,460,000	7 Mineral lubricants
	3,840,000	8 Spirits turpentine
3 Caoutchouc	2,582,000	
	2,220,000	9 Crude benzine
	2,171,000	10 Beef tallow (prime)
	1,744,000	11 Nickel and nickel coin
4 Straw, esparto and other fibers; paper stock	1,649,000	12 Cotton-seed oil
	1,550,000	
5 Alizarin and anthracene dyes	1,463,000	
	1,421,000	13 Pig lead and scrap
6 Indigo	1,319,000	
	1,231,000	14 Crude and hard paraffin
	1,162,000	15 Acetate of lime
7 Platinum and allied metals	1,120,000	
8 Hops	952,000	
9 Miscellaneous volatile oils	941,000	
	903,000	16 Tin and tin scrap
10 Tin and tin scrap	900,000	
11 Potassium and sodium cyanide	845,000	
12 Chrome, tungsten, etc.	784,000	
13 Superphosphates	766,000	
	724,000	17 Crude wood alcohol
14 Beet sugar, refined	716,000	
	695,000	18 Carbides
	673,000	19 Miscellaneous volatile oils
15 Alkaloids exoquinone	672,000	
16 Toilet and tooth powders	658,000	
	656,000	20 Heavy benzine and patent naphtha
17 Lime-nitrogen, etc.	635,000	
18 Potash carbonate	632,000	
	617,000	21 Lubricants of fats and oils
	579,000	22 Beef and mutton tallow
19 Ferro-Al, Cr, Mn and Ni	567,000	
20 Potassium magnesium sulfate	509,000	
21 Gold ores	506,000	
	506,000	23 Copper alloys
22 Beet sugar, raw	492,000	
23 Aniline oil and salt	476,000	
24 Bronze and metal colors	473,000	
25 Glue	471,000	
26 Aluminum plates and metal	454,000	
27 Quinine and its salts	436,000	
	422,000	24 Portland cement
28 Terpineol and allied synthetics	409,000	
29 Gelatin	403.000	

RELATIVE QUALITIES OF IMPORTS AND EXPORTS.

Of course, it will be contended that the things that we sell Germany are, from a chemical point of view, less refined, i. e., involve less hard chemical intellectual work than do our imports from Germany. But, is most of the potash, which is practically mined from the ground in Germany, any more of a refined product than the phosphate rock we sell them? Does it not involve quite as much chemical ingenuity to produce good illuminating oil from petroleum as it does to produce many of the coal-tar dyes? There is no question that the general position above outlined is correct, namely, that our products, as a whole, are less refined than those that we get, as a whole, from Germany, but is that not true practically throughout our entire export and import business? Are not the textiles we export of a lower grade than those we import? Are not our leather products less refined than those we buy? And so on down the list. That being so, why pick out the chemist as a special mark for criticism when he is at least up to the average of his surroundings?

In 1913 the total foreign business of the United States amounted to $4,227,348,909, and the excess of exports of all kinds over imports of all kinds amounted to $691,-271,949.

The trade in chemicals and products of and for chemical industry between the United States and Germany in 1913 furnished 5 per cent of that total of international business and provided 13.8 per cent of the balance of trade.

THE INFLUENCE OF THE CHEMIST.

The symposium of papers presented to-day constitutes a record of proud achievement, of solid accomplishment in nineteen different branches of American industrial activity, to which advance the application of chemical knowledge, chemical principles, and chemical experience by American chemists has contributed a noble share and an effective part. It is perhaps true that much of that progress would have come without the American chemist, but it is equally true that under those conditions the advance would have been much slower and also much of what has been accomplished would never have happened at all without the faithful, enthusiastic and alert co-operation of the American chemists on the job. With such a record, the American chemist can hold up his head with pride and self-confidence, firm in the belief, and warranted in his conviction that he has done a man's work, in a man's way, that he has not been an idler, nor a sloth, nor a drone, but that he has been one of the busiest of busy workers, with a keen eye and an alert intellect, always searching for an opportunity for the betterment of his industry, and for improvement of the conditions of his fellowman.

GERMAN SUPREMACY.

That the chemist has not done more is by no means due to any unwillingness. It is due in the largest part to the apathetic attitude of those in charge of the management of many of our industrial enterprises requiring chemical knowledge in their exploitation. Many of these men in responsible positions do not have a chemical education even along the lines in which they are financially active. In those cases chemical novelties and chemical problems are not passed upon, on their merits, by chemists or by men with a chemical point of view, but by merchants, by lawyers and by bankers, men who, by their very training, are not capable of taking the chemist's point of view, of having the chemist's sense of proportion, and are unwilling to take a chemist's chance in a chemist's way. Therein lies, perhaps more than in any other one thing, the reason for Germany's supremacy in most of the branches of chemical industry. That also is the reason for the success of a great many of our own huge transportation, electrical, and chemical enterprises. The business is run by men who know it from the technical point of view. Railroads are run by men who know the railroads from the operating and construction point of view; electrical enterprises by men who know the business from the electrical engineer's point of view, and they make their enterprises take their business chances in a transportation, and in an electrical way. Practically all of our chemical enterprises that have been managed in the same manner have also been successful, but there is still great room for improvement, and just as soon as that improvement is accomplished, just so soon, and no sooner, will there be less and less talk about the incompetency of the American chemist. German chemical enterprises are run and managed by chemists.

THE RESPONSIBILITY OF THE CHEMIST.

The chemist must not attempt to absolve himself from all responsibility for the prevailing lack of appreciation or skepticism among capitalists and bankers of the value of chemical work in industrial operations. While competent chemists and chemical engineers by their very effective work have wrung from reluctant financial men proper acknowledgment of the value of chemical examination, control, and management of enterprises requiring such, yet the work has not gone far enough, and it is not at all unusual for financial men to support with might and main enterprises which any qualified chemist or chemical engineer could and probably did tell them were foredoomed; also it must not be forgotten that qualified chemists and chemical engineers, like other professional advisers, have gone astray in their calculations and have supported enterprises which ultimately failed. The mining, electrical, and railroad engineers finally succeeded in obtaining their present influential position among the industrial councils of this country, and with the brilliant success of the chemical engineers of Germany in the same direction it is not too much to hope that ultimately the American chemist and chemical engineer will come into his own. When he does, there will be far fewer exploitations than heretofore of the wild and fantastic schemes of chemical enterprise now so easily financed by the gullible portion of our investing public and fewer and fewer failures of chemical enterprises undertaken in good faith and serious mood.

Therefore, let every chemist in advising on chemical operations prominently bear in mind that failure to give correct advice not only reacts upon him but upon each and every member of the chemical profession and merely helps to postpone the day when the chemist will come into his proper position among the makers of the nation.

CONGRESS AND CHEMICAL INDUSTRY.

Like every other industry, all the branches of chemical industry are dependent for their ultimate success upon economic conditions. They must be able to sell at a price greater than their costs. It is not enough to have the material, the men, and the "know how"; you must have the market as well. However, the attitude of consumers of chemicals in this country has habitually been opposed to the creation in this country of conditions favorable to the manufacture of chemicals.

The following quotation from an address in 1910, by Dr. W. H. Nichols,[1] presents this aspect of the problem completely.

"If a comparison were made between the chemical industry of this country and that of other countries, it would be found that the industry in this country in most respects is fully on a par with that of any other country, and in some respects is well in the lead. It is a public notion that our industry is coddled by the tariff, and is thereby based upon a somewhat insecure foundation. Like many other public notions, this is not true. It will be seen by casual examination of the imports that there are a number of chemicals which are not made in this country at all, and a number of others which are made only to a moderate extent. This is not due as much to lack of enterprise of the chemical manufacturers as the fact that the tariff is distinctly unfavorable to the manufacture of many chemicals which are produced in Europe on a large scale and whose manufacturers use this country as a "dumping ground." In our tariff all chemicals, unfortunately, are enumerated in Schedule "A." It has been the history of several revisions of the tariff that these revisions have been approached with a firm intention on the part of our legislators to lower the tariff, and they have begun on Schedule "A" with a great deal of enthusiasm. The rates of duty of this Schedule have been steadily reduced, and many articles placed upon the free list before the log-rolling, which is popularly supposed to form such an important part of all tariff inquiry, has begun to get in its work; hence the chemical industry has met with constantly lower tariff rates, while the materials which it has to use have often been left in a position unfavorable to chemical manufacturers. In the interest of fair play, it is to be hoped that when the tariff shall again be revised our legislators will begin at the other end of that document.

"I think it may be stated safely that the chemical manufacturers of this country do not ask and have not asked any favors of the people which would result in any way in a fictitious advance in the values of their output. It is also fair to state that the chemical manufacturers of this country, while entirely friendly to one another, are in no way connected by agreements or 'pools.' While there may be exceptions to this of which I am not aware, I think this can be put down as a general statement, and I am sure it will be believed by all consumers of chemicals who come in contact with the active salesmen of the numerous companies."

It is, therefore, only fair to say that the American chemist and chemical manufacturer has throughout made the most of his opportunities, has made his fair contribution to the country's need and growth, and has taken a fair and proper share in the internal and international business of the United States. The people of the United States, speaking through Congress, have repeatedly told the American chemist and the American chemical manufacturer "so far and no farther will we help you." The chemist and manufacturer have done all that can be accomplished under those circumstances; if they could not attract capital to all the enterprises they desired to found it was for the reason that capital could be more profitably employed otherwise and money has the stubborn habit of going where it can obtain the biggest return—long waits and uncertain results have no attractions for it.

(To be continued.)

Tincture of White Soap*

It is assumed that when a surgeon is washing up, in preparation for an operation, the aim is to thoroughly cleanse the skin and to remove all grease and other matters which are liable to entangle or harbor bacteria. For this purpose, soft soap is generally employed, either as such or as made up into tincture of green soap, or other similar alcoholic solutions.

Three objections to soft or green soap appear, viz.: (1) It carries much free alkali, which tends to roughen the skin; (2) it has a disagreeable odor, often masked by the addition of oil of lavender or carbolic acid; (3) it clings to the skin and cannot readily be so completely removed that no odor is left.

With the aim of preparing a liquid soap which will not carry these objections, I sought to substitute for this use white castile or Marseilles soap. This soap is soluble in about 9 parts of cold water and in about 17 parts of alcohol, which solutions are far too dilute for the use in question.

"White soap," however, is soluble in about two parts of dilute alcohol, and the addition of a little ammonia further increases this solubility, so that with it we can obtain a solution containing as much true soap as is present in an equal volume of tincture of green soap. (Note that green soap, as sold, retains the glycerine of the oil and much water.)

The name and formula proposed for this preparation is as follows:

TINCTURE OF WHITE SOAP.

			For 1 gallon.
℞	Of white soap, Conti's	300 gram.	1,200 gram.
	Of ammonia stronger	25 c. c.	100 c. c.
	Of alcohol	350 c. c.	1,400 c. c.
	Of water, dist.	325 c. c.	1,300 c. c.

The specific gravity of this is 0.97, which is identical with that of tincture of green soap.

To make one gallon: Mix the liquids for it in one gallon jar and then add the soap, previously cut into coarse shavings. Crowd all the soap into the jar and cover it with a glass plate. After 12 hours stir, and again stir after some hours. Allow to settle 12 hours and then filter, decant or syphon off the clear liquid into a can which may be kept closed. There will remain a few ounces retaining the impurities of the soap, which may be used for less particular washing. If this liquid is exposed to evaporation for a few hours, ammonia and alcohol escape, and a mass of the consistency of green soap will be obtained.

This form of soap alone has been employed by the surgeons in the University Hospital for the past year or more. While this preparation is free from the three above mentioned objections to tincture of green soap, it presents the additional advantage of costing but $1.50 per gallon, and, if the alcohol be obtained tax free, the cost will be about 60 cents per gallon, while tincture of green soap will cost one dollar or more.

[1] *J. Soc. Chem. Ind.*, 29 (1910), 1448.

* Read before the Medical Section of the Philosophical Society of the University of Virginia.

Fig. 1.—Loading a sherardizing drum.

Sherardizing for Rust-Proofing Metals*

The Process, the Apparatus and Methods Employed

By Chester L. Lucas†

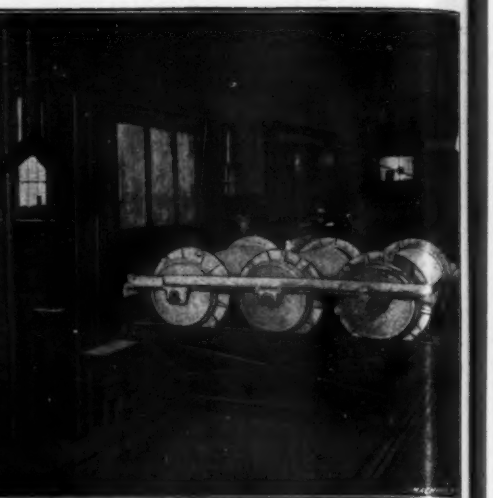


Fig. 2.—Charging one of the furnaces.

Numerous processes are employed for rust-proofing metal articles. Of these one general class is based on the application of a coating of zinc to the work. Of the zinc-coating processes, the oldest in common use is undoubtedly hot galvanizing. This is essentially a dipping operation in which the work, after being properly cleaned, is immersed in a tank of molten zinc. Another method of rust-proofing is the electro-galvanizing process which had its inception before hot galvanizing, but only until within the last few decades has it come into use. This is an electro-plating process, in which zinc is deposited from an anode onto the work. In addition to these two processes, there are others based on the immersion of the work in solutions of different kinds, and at least one in which the zinc dust is sprayed on the work while hot. Another zinc-coating process is sherardizing and it is the purpose of this article to outline the practical side of this interesting process.

THE SHERARDIZING PROCESS.

The sherardizing process was originated in England by Sherard Cowper-Coles about 12 years ago. Briefly, the process consists in sealing the work to be sherardized in metal retorts in conjunction with metallic zinc dust. The retorts are then heated until the work at the center has reached a temperature of from 500 to 700 deg. Fahr., depending upon the nature of the work; at the same time the retorts are turned intermittently so as to give the zinc dust access to all parts of the work. After holding this heat for several hours, the time depending on the thickness of the coating desired, the drums are taken from the furnace and allowed to cool. When cool the work is finished. The sherardizing process can be applied with advantage to a great variety of articles, however intricate. These range from a watch screw to a roll of wire fencing. A sherardized surface is light gray in color, and the finish imparted is a fine matted surface resembling that obtained by sand-blasting. Fig. 3 shows a sherardized surface magnified 70 times which accounts for the rough appearance.

The action that takes place in sherardizing consists in forming both a zinc-iron alloy and a coating of zinc upon the material to be treated. The zinc dust becomes partially vaporized under the influence of the heat applied, and the vapor thus produced in condensing upon the hot iron forms the protecting coating, the inner layers of which alloy with the iron, while the outer layers provide additional surface protection of nearly pure zinc. Fig. 4 will perhaps make this point clear. This shows a section through a piece of low-carbon steel that has been sherardized. This has been magnified 1,300 times and plainly shows the body of the steel, the zinc-iron alloy section and the pure zinc coating above. It should be explained that this photograph was taken of a section formed by cutting through the stock and polishing the surface.

ADVANTAGES OF THE SHERARDIZING PROCESS.

Sherardizing has advantages over other methods of zinc coating, which may be classed under two heads; first, the superiority of the product and second, the economy of the process. The fact that the zinc coating penetrates unlike any other method of zinc coating, and amalgamates with the iron, makes a finish that cannot be worn or eaten away. In addition, the coating is so evenly applied and so thoroughly driven into the surface of the metal that it does not alter the exterior of the article to any appreciable extent. In fact, sherardizing is perfectly practical for the protection of threaded screws of fine pitch and it is not not necessary to recut them after the coating has been applied if a slight clearance is made when cutting the thread. Because of the nature of the process every part of the article treated is reached, the insides of tubes or sharp corners are coated just as thoroughly as the more exposed places. The depth of the coating may be controlled by the metallic percentage of the zinc dust, the length of time the heat is applied and by the temperature to which the retorts are subjected. There is no distortion of slender pieces or thin objects such as might occur when using the hot dip, because in sherardizing the heat is applied gradually and the work just as slowly cooled off.

The economy of the process is at once evident by the low heat required, the temperature of 500 to 600 deg. Fahr. being far below the melting point of zinc, which is 786 deg. Fahr. Less zinc is required because none is wasted. The thin but thorough coating that is applied is just as effective as the thick rough coating that the hot galvanizing process gives. A sherardized coat of one-half ounce to the square foot affords more protection than a galvanized coating of 1½ ounce to the square foot. No flux is necessary and the presence on the work of non-fatty oil in a moderate degree does not interfere with the sherardizing.

There is practically no limit to the metallic products that may be sherardized; in fact any articles that may be placed in the drum may be so treated. Oftentimes drums of special shape may be made to accommodate certain products. Screening, wire, etc., may be handled just as effectively as inflexible material by coiling it and placing it in that state in the drum. After sherardizing, the wire or screen may be straightened without injury to the coat of sherardizing.

Practically the only limitation to the sherardizing process is the fact that on very small tempered steel articles such as springs, the heat of 600 degrees or thereabouts will draw the temper, leaving the metal in an annealed condition. On most work, however, this is not objectionable.

The process of sherardizing is not confined to the coating of the product with zinc alone, but aluminum, tin, etc., are also used for sherardizing to good advantage. Zinc, however, is the leading metal on account of its ability to resist corrosion, due to its being electro-positive to iron.

ZINC FOR SHERARDIZING.

The zinc dust used in the process of sherardizing is commercial zinc dust, of which at this time about 90 per cent is imported. On an average, the composition of this material runs about 90 per cent metallic zinc and 10 per cent zinc oxide. Zinc dross is sometimes used, but not very successfully, as it will not alloy with the work being treated as intimately as the finely powdered zinc dust, although when the two are combined in equal parts they show good results. The best results are obtained when the zinc dust has been reduced to about 50 per cent metallic by the addition of spent zinc; therefore, new zinc should be reduced to that percentage as rapidly as possible.

Sherardized material require a deposit of 4 pounds of zinc per 100 pounds of material treated, as an average. After the zinc has been reduced to the right percentage it may be held at that strength by simply replacing 4 pounds of new zinc for every 100 pounds of material treated, taking care that it is thoroughly mixed with the spent zinc dust. A chemical analysis of the dust in use once a month is recommended.

CLEANING THE WORK.

Sherardizing, like other zinc-coating processes, should have a clean surface to work upon. The presence of scale, rust or dirt greatly interferes with the sherardizing

* From *Machinery*.
† Associate Editor of *Machinery*.

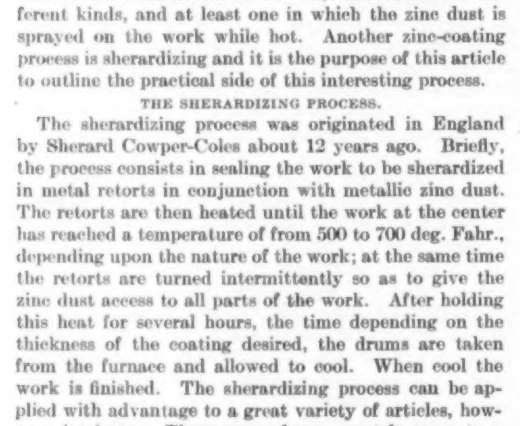


Fig. 3.—Appearance of a sherardized coating, magnified 70 times.

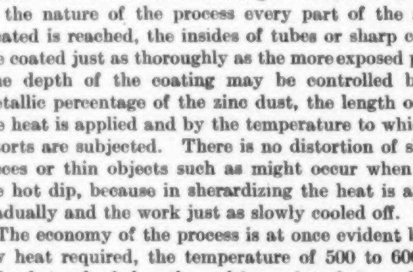


Fig. 7.—Turning the drums.

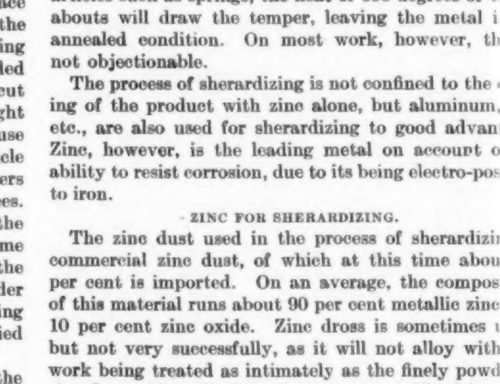


Fig. 4.—Enlarged cross-section photographed through a piece of sherardized steel magnified 1,300 times.

action. Machine products like screws and bolts require no cleaning other than an alkali dip. Sand-blasting is employed for cleaning relatively large pieces and an acid pickle is the common medium for removing scale. After cleaning with acid by the pickling process, the work should be thoroughly neutralized by placing it in a boiling solution of cyanide (mixture, 1 pound cyanide crystals to 20 gallons of water). A bright coating of zinc is assured, by taking these precautions.

The claim has been made that articles coming direct from the machine covered with oil can be sherardized without cleaning. This is true where no fats are used with the oil, and the zinc dust is new and of sufficient metallic strength to force itself through the oil. However, experiments along these lines have proved that after several operations, the material will come out very dark; therefore, considering the small cost of cleaning it should not be neglected.

PACKING THE DRUMS.

The drums in which the work is packed with the zinc dust may be of any convenient shape and size to fit the furnace in which the work is to be done. The one shown in the illustration Fig. 4 is 4½ feet long and 15 inches inside diameter. These are made of boiler plate with flanges at each end, upon which the end caps are bolted. In the event of the work being too long for the drum, two of these drums may be bolted together, making an extra long drum. The operator shown in Fig. 1 is loading the drum with chains which he takes from the barrel that may be seen at the right. In the drum shown, about 350 pounds of chain may be accommodated. The drums are filled in the same manner that a casehardening heat is prepared, first a shovelful of the zinc dust and then a shovelful of work is placed in the drum, and so on until the retort is filled to within about 2 inches of the top. This space is left to provide for expansion of the contents.

After the heads have been bolted on the drums, they are ready for the furnace. Fig. 2 gives an adequate idea of the way a sherardizing furnace is charged for firing. The laborer who fills the retort, loads them upon a skeleton truck, the top of which has a cross track from which the drums may be rolled into the furnace by means of wheels slipped over their ends. It will be noticed that the drums are spaced and held by an angle iron frame. This view shows the square sockets in the drum-caps, by means of which the drums may be turned while the sherardizing is going on.

THE SHERARDIZING FURNACE.

The requirements of a furnace for sherardizing are not severe. On account of the fact that the maximum heat required to be imparted to the work is only from 500 to 700 deg. Fahr., illuminating gas, natural gas, oil, coal or even coke may be used. The New Haven Sherardizing Company is paying special attention to coke furnaces. In other lines of work coke furnaces have not been in general favor on account of the low amount of heat to be derived from this fuel, but as coke will give a sufficient heat for sherardizing, the economy of the coke furnace is apparent.

Figs. 5 and 6 show a new coke furnace made by the New Haven Sherardizing Company, for the purpose of sherardizing. This is a coke-burning furnace, although it can be used for soft coal or, in fact, any other fuel. It is especially valuable in urban districts where no liquid or gaseous fuel is available. The operating cost of this furnace is practically the same as for natural gas or producer gas. As Fig. 6 shows, it is made on the arch construction plan, employing a double arch. One of these arches is over the work chamber or oven and the second arch, which is larger, embraces the first arch and

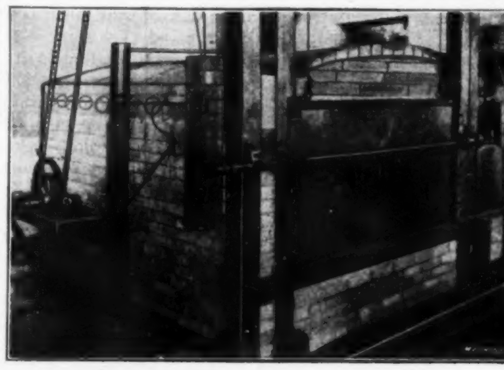


Fig. 5.—A coke burning sherardizing furnace.

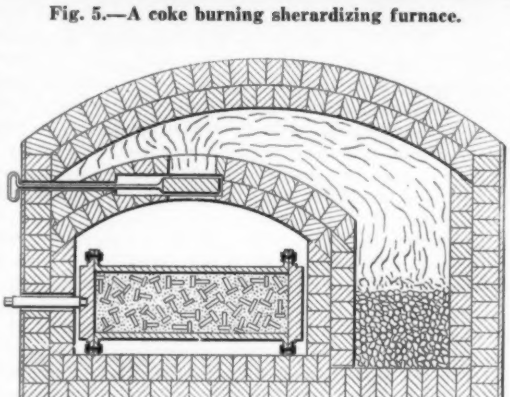


Fig. 6.—Section through the coke burning furnace.

also the coke burning pocket at the side. Near the center of the arch over the work chamber, there are a number of rectangular openings. The heat passes up from the coke pocket to the top of the large arch, and is drawn downward through the rectangular openings into the furnace and onto the work. Each of these several openings is controlled by a separate damper whose handles may be seen at the left-hand side of the furnace in Fig. 5.

The furnace has an automatic drum turning feature which provides for the turning of the sherardizing drums at stated intervals. Intermittent turning of the sherardizing drum gives better results than the continuous rotation practice that has been advocated by some authorities. The work is much cleaner and brighter if not continuously rotated during the sherardizing process. In those plants where continuous rotation is practised, the drums are turned one revolution every two minutes. When turned by hand intermittently, the operation is performed as shown in Fig. 7. Short squared shafts extend through the furnace wall and into the sockets in the ends of the drums. Every 15 minutes the drums are given a half turn to mix the contents thoroughly and allow the heat and zinc to have access to all parts of the work. From the above, it will be seen that there are three methods in vogue for turning the sherardizing drums while under heat: viz., continuous rotation, automatic intermittent turning and intermittent turning by hand. Above the squared shafts shown in Fig. 7 may be seen the pyrometer that indicates the furnace heat.

The temperature at which the furnace is kept varies according to the size of work being sherardized. From 500 to 700 deg. Fahr. marks the range limits, large work requiring the higher heat. The drums are kept heated for a period varying from 4½ to 5 hours, according to the depth of the sherardizing coat that it is desired to give the work.

REMOVING THE WORK.

At the end of the prescribed time that the drums are kept under heat, they are rolled out of the furnace and allowed to cool slowly until they may be handled without inconvenience. For the unloading operation the drum is hoisted to the mouth of a rotary screen and there emptied, the contents passing through the rotary screen. The work emerges at the outer end, while the zinc dust drops through the screen and out of the way. It will be seen that the mouth of the screen leads out of a forge-like structure that catches the work as it is pulled from the drum and allows the floating dust to be carried away in the exhaust overhead. The work emerging from the farther end of the screen is caught in a second screen and the process repeated until at the end it is perfectly clean and free from all zinc dust.

THE COST OF SHERARDIZING.

There are four charges that enter into the cost of sherardizing. First is the royalty that must be paid to the owners of the process, second the labor cost, third the cost of the zinc dust and fourth the fuel charge. The royalty is in all cases approximately $2.50 per ton of material sherardized. The cost of the zinc dust required for a ton of work varies with the size of the work but is approximately $5, based on the use of 80 pounds of dust at 6¼ cents per pound. The labor cost for handling a ton of average work would be about $3. The fuel cost varies, being for producer gas $1.75 per ton, for illuminating gas $4 per ton, for natural gas 75 cents per ton, for crude oil 90 cents per ton and for coke 75 cents per ton. From these figures it will be seen that expense is no barrier to the use of this most efficient of rust-proofing processes.

London Traffic Dangers

With the continued absence of effective measures of control and for the relief of congestion, London's traffic problem steadily increases in complexity, and, unhappily, the tale of street accidents as steadily grows. Statistics published in the annual report of the London Traffic Branch of the Board of Trade, issued recently, show that in the last decade accidents caused by road vehicles in the metropolitan area have more than doubled, and that the proportion to population is continuously rising.

It is true that people travel much more than they used to do. In 1904 the journeys per head of the population were only 150.5; in 1913 they were 271.5, an increase of 80.7 per cent. But the corresponding totals of street accidents were 11,967 in 1904, and 25,839 in 1913, an increase of 115.9 per cent. Fatalities in particular have become much more numerous, and there can be no doubt (says the report) that this is largely due to the multiplication of motor vehicles.

In 1913 power-driven vehicles again caused some 2,000 more accidents than in the preceding year. Nor was the previous decrease maintained in those caused by horse-drawn vehicles, an actual increase over 1912 being shown in 1913. In the four years 1910-13, 45,366 accidents were caused by power-driven vehicles, and 43,077 by other vehicles, including cycles.

Three per cent of the accidents due to power-driven vehicles in 1913 proved fatal, and 2% per cent in the case of horse-drawn vehicles. That this is largely due to weight is shown by the relatively high percentage of accidents in the case of the heavy motor car and the motor 'bus, with 8.7 and 5.4, respectively. On the other hand, the electric tram, the heaviest vehicle of all, with its low percentage of 1.6, is an exception, and this is accounted for by the high efficiency of the lifeguard, which has been the means of saving many lives.

While the motor 'bus still heads the list with the largest number of deaths—556 in the four years—the danger of these vehicles, in proportion to the work done, has largely decreased. There is no doubt that the fitting of the side wheelguard has had a very beneficial effect in checking the number of accidents, and the latest returns go to show that the improvement was still more marked in 1914.

Investigation proves that as a whole power-driven vehicles are twice as dangerous as horse-drawn vehicles, while the cycle is slightly less dangerous than any other type of vehicle. As regards causing death, the differences are much more marked. The cycle is by far the least fatal, and considered as the unit to which the other vehicles are referred, the electric tram and horse vehicles come next, being nine times as fatal, the motor cab eleven times, motor cars twenty-three times, and motor 'buses thirty-eight times as fatal as the cycle.

It is added that setting up of a large number of additional refuges, and the compulsory fitting of guards to the sidewheels of all motor omnibuses have already done much, and will do more, to check the rate of increase in accidents. It would also be advisable that the heavy commercial motor cars now in use should have similar guards fitted, but in view of the fact that the average of the three years 1910-12 showed that 55 per cent of the fatalities were due to the inadvertence of the pedestrian, the best hope of further improvement seems to lie with the pedestrian himself, and there is no doubt that the average person is now much more careful than he used to be.

In 1913 the number of passengers carried by railways, tramways, and omnibuses in the London area reached the colossal total of 2,007,348,055. Of these 462,019,537 were railway, 811,397,317 tramway, and 733,931,201 omnibus passengers. The total represents 271.5 journeys per head of the population. In 1903 the aggregate was 972,465,682, equivalent to 144.9 journeys per head. In addition, cab journeys in 1913 are estimated at over 50,000,000.

Horse drawn vehicles continue to be supplanted with remarkable rapidity by those mechanically propelled, and the extinction of the horse for passenger purposes seems now almost in sight. Some years may elapse before this result is achieved among trade vehicles, but the motor is adding very largely every year to the importance of arterial communication by road. The observations show that in 1914 only 4 per cent of the passenger vehicles were horse drawn, compared with 6 per cent in 1913, 11 per cent in 1912, and 13 per cent in 1911, and that in 1914 85 per cent of the trade vehicles were horse drawn, compared with 88 per cent in 1913, 91 per cent in 1912, and 94 per cent in 1911.

As showing the growing inadequacy of the main arterial roads, it is stated that the total horse and motor vehicles enumerated at 84 points, fairly distributed all over London, increased in 1914 by 19.2 per cent over the figures for 1911. "The greater part of this increase occurs in the zone from six to nine miles from St. Paul's Cathedral, which is precisely the area wherein it is of such absolute importance to deal with the question of road improvement without delay. The fact that estate development has already blocked some of the selected routes should convey a serious warning that there is no time to lose in dealing with other sections of roads on the outskirts, if exits from London, at present available, are to be saved from the same fate."
—*The London Daily Telegraph.*

The Zeppelin Question

Facts and Figures Indicating the Number and Capacity of the Air Fleet

So much has been said about the monster Zeppelin airships, what they were expected to do, what they have accomplished, and what use may be made of them in the future, that the following examination of the factors of these big craft by Georges Prade, published in *Le Journal* and translated by *Flight*, will be read with particular interest at this time. M. Prade's article is as follows:

The Zeppelin question has become to a certain extent—and, perhaps, entirely so—the question of the day. After not having believed sufficiently in the Zeppelin, there are now people who believe too much in it. Permit one, who has followed the matter from the first, and who has appreciated the splendid efforts of Count Zeppelin, to examine, figures in hand, and in the light of cold reality, the probable actual state of the German aerial fleet, the nature, value, and number of its units, the possibilities and the exact conditions of a raid on London or Paris.

The real offensive value of the German aerial fleet is the sum of efficiency and number of the units that compose it. Let us, therefore, establish these two points, and commence by defining what a modern Zeppelin is. The imagination has been given free play on this subject, and, as if the Zeppelins were not already monstrous enough, rumor has made them even larger. Some writers have gone so far as to talk of "super-Zeppelins" of 400 yards in length, which presumes a trifle of 300,000 cubic meters. It can be stated without hesitation that the modern German dirigibles are of the same tonnage as before the war, which is, of course, necessary for their rapid manufacture. Material proofs of this statement, of which the first, sufficient in itself, is the actual dimensions of the German sheds, are obtainable. The longest shed in Germany, that at Leipzig, is 193 meters, and those at the works of Friedrichshafen, which have not yet been enlarged, are 178 meters long. The rotatable shed at Cuxhaven, which cannot be enlarged, is 180 meters. Those at Cologne, Metz, and Baden are only 158 and 160 meters. The French *hangar* at Maubeuge has lately been enlarged to 160 meters by the Germans. The two 1914 types of Zeppelins measure: The 22,000 cubic meters army airship, length, 156 meters; diameter, 14.8 meters; width over the propellers, 22.5 meters; and height, 18.8 meters. The 27,000 cubic meters naval airship, length, 158 meters; diameter, 16.58 meters; width over propellers, 22.8 meters; and length, 19 meters. These figures represent, therefore, the maximum size airship which will enter the actual German *hangars*. It has been possible to improve their economy, but their tonnage, and consequently their radius of action, useful load, maximum attainable height, and speed are the same to-day as they were in July last. This radius of action is sufficient not only in times of peace, but also in war time, as evidenced by the Cuxhaven-Yarmouth-Cuxhaven raid. The length of this was 730 kilometers [453 miles], or equal to a cruise from Frankfort to Paris and back, or Cologne to London and back. Airships of the same type and carrying the same load can, therefore—theoretically, and speaking from the aeronautical point of view—repeat the performance, starting out from a sufficient number of sheds.

What are these airships? What weight of bombs do they carry? We know that the Germans have naval airships of a known type, and of 27,000 cubic meters capacity. Let us first attempt to calculate their load of explosives, as this will serve as a basis for the estimates of modern ones.

Let us state, first of all, that the lessons of experience (the bombardment of Antwerp, Ostend, Ghent, of the Belgian campaign, of Warsaw, Plock, Nancy, the English coast, and Libau) have up to now been very reassuring. In each case there was no real bombardment, and the cruisers of the air, which were the same in numbers as at Yarmouth (two or three) have dropped few bombs; bombs, moreover, which were of light weight and small effect. There were twelve deaths at Antwerp, not a single one at Ostend or at Ghent; forty deaths from five bombardments in Poland, two at Nancy, four in England. This gives a total of about sixty victims, that is to say, the crews of two large Zeppelins, all in six months of campaigning, and after fourteen attacks, during which period the flotilla lost at least five units. Nowhere have bombs been found weighing more than 49 kilogrammes [108 pounds] (this was the weight of the bomb found intact at Yarmouth).

The estimate of the useful load which a Zeppelin will carry will explain this mystery, which cannot be ascribed to Teutonic modesty.

The Germans have carefully withheld these figures from us. In the German *Taschenbuch* of the aerial fleets, the useful load of Zeppelins does not appear. We have, however, fairly exact data to go on. The first were furnished at the time of the landing of "Z-4" at Luneville in April, 1913. This airship was of the 19,500 cubic meters [23,505 cubic yards] type (141 meters by 14.8 meters—462.5 feet by 48.5 feet). The total lift was, therefore, about 20,500 kilogrammes [45,195 pounds], but the ship's books showed that the dirigible itself, framework, fabric, motors (three Maybach of 180 horse-power each, and each weighing 448 kilogrammes—988 pounds), only left available a lift of 4,800 kilogrammes [10,582 pounds], which works out at 23.9 per cent of the total load.

From these 4,800 kilogrammes must be subtracted 950 kilogrammes [2,094 pounds] for the crew (twelve men), and 135 kilogrammes [298 pounds] of gasoline and oil per hour, which makes, for a six hours' cruise (360 kilometers—224 miles), 810 kilogrammes [1,785.75 pounds]. Finally, in order to reach a height of 1,900 meters [6,234 feet], hardly a sufficient altitude, "Z-4" had to jettison 3,000 kilogrammes [6,612 pounds] of ballast. The "Z-4," therefore, had exhausted its whole useful lift in a six hours' cruise and covering a distance shorter than that from the nearest German shed to Paris or London and back, without counting projectiles, ammunition, armament, and *personnel*. It can therefore be stated that, except by flying very low, and thus running the risk of being brought down, the Zeppelins of the 19,500 cubic meters capacity or less, are unable by far to solve the problem.

It is for this reason that Germany in 1903 constructed types of 22,000 cubic meters capacity [28,775 cubic yards], 156 meters long [512 feet] by 14.8 meters diameter, that is to say, of the same diameter as the older ones, but with more ballonets (18 ballonets instead of 16). The power and weight of the motors is the same, as is also, for all practical purposes, the speed. Nevertheless, the weight of the gas chamber has been increased by two ballonets, and the following estimate can be made: The weight of the gas chamber and of the keel has been increased by about an eighth, a weight which has to be subtracted from the extra lift of 2,600 kilogrammes [5,732 pounds] furnished by the increase in cubic capacity. Further, the extra weight of fuel for four hours which is required in order to give the dirigible the necessary range of action for the raid in question (ten hours' cruise of 600 kilometers—373 miles) has to be subtracted. This is an addition of 540 kilogrammes [1,190 pounds], which brings the total weight of fuel up to 1,350 kilogrammes [2,976 pounds]. A crew of twelve men is insufficient, especially in view of the fact that the dirigible is to be fitted with machine guns and gunners. The 27,000 cubic meter type had twenty-eight men on board (the number of victims in the catastrophes that overtook "L-1" and "L-2"). If, in this case, we only take eighteen men, that would be an extra load for the crew of 500 kilogrammes [1,102 pounds]. Then we must subtract the weight of the machine guns, of their ammunition, of two searchlights, and of the sheet steel armoring for the motors, which is 2 millimeters thick and weighs 14 kilogrammes per square meter.

We therefore see that the 22,000 cubic meter type with full war equipment and bound for Paris or London cannot carry anything like a ton of explosives.

There now remains the 27,000 cubic meter [35,314 cubic yards] type, which has theoretically 6,000 kilogrammes [13,228 pounds] more lifting capacity. But it has a diameter of 16.58 meters [54 feet] instead of 14.18 meters, and is 158 meters [519 feet] long instead of 156 meters. It has four motors of 180 horse-power each instead of three, and a crew of twenty-eight to thirty. The first Zeppelin captured at Warsaw had thirty men on board. The expenditure in fuel increases by a tenth. The figures given by the Maybach Works, which are, however, a minimum, give 229 grammes [about 8 ounces] of gasoline per horse-power hour and 2.5 kilogrammes [5.5 pounds] of oil per hour for each motor.

The raid on the English coast represented, out and back, a distance of 732 kilometers [454 miles] and a cruise of more than twelve hours' duration, since the "L-3," the record breaker, with a maximum speed of 70 kilometers [44 miles] per hour, has never been able to do more than an average speed of 60 kilometers per hour, which will give, including the reserve of fuel necessary in case of wind, 14 hours' fuel, or 2,268 kilogrammes of gasoline and 140 kilogrammes of oil—a minimum of 2,308 kilogrammes [5,089 pounds].

Let us now work out these supplementary loads; 500 kilogrammes for the fourth motor. In the "L-2" there was one more boat. In the "L-3" the second rear *nacelle* has been enlarged and the central cabin and the keel retained; say another 500 kilogrammes. Increase in gas chamber 5/22nds, meaning at least 3,000 kilogrammes; increase in ballast take 500 kilogrammes. (The "L-3" had to leave eleven men of the ordinary crew on the ground in order to be able to increase the attainable height from 420 meters to 3,125 meters [10,250 feet], the Zeppelin record, established on May 16th, 1914. This gives an extra height of 2,700 meters climbed in 3 hours 30 minutes at the expenditure of a special discharge of 1,000 kilogrammes, including the weight of the eleven men of the crew.)

Weight of supplementary crew, 600 to 800 kilogrammes. Total, 6,100 kilogrammes, which, even by reducing the ballast and crew, gives us the same weight of explosives, 1,000 kilogrammes [2,204 pounds] at the most, transported it is true, a longer distance, 730 kilometers instead of 540 kilometers.

The large naval dirigibles which appeared over the English coast certainly had not 1,000 kilogrammes [2,204 pounds] of explosives on board, which is proved by the fact that they did not throw that weight. I do not suppose that they would have carried their bombs back to Cuxhaven. These weighed at the most 50 kilogrammes, and each carried at the outside twenty bombs. Other figures confirm this estimate. Six bombs were thrown at Antwerp, three at Ostend, five at Ghent, fourteen at Nancy (three airships were of the 19,500 and 22,000 cubic meter type), and let us suppose that there were thirty bombs to two dirigibles over England, and eighteen at Warsaw (these must have been naval airships, as the Russians captured thirty men on board). For a raid on Paris or London, the mean distance of which is shorter, this figure of 1,000 kilogrammes of explosives would therefore serve as a good basis.

Let us add that the maximum speed of the Zeppelin is about 72 kilometers [45 miles] per hour. The best performance is that of the "Z-VI" (19,500 cubic meters, 540 horse-power), Brunswick-Leipzig-Brunswick, 3[illegible] kilometers in 4 hours 40 minutes, which gives 68 kilometers [42 miles] per hour. (May 16th, 1914.) The greater ones are much slower.

There now remains to work out the number of the units which we have dealt with.

There were before the war thirteen Zeppelins, of which one was almost destroyed—the "Z-II," brought down at Thionville; the other nearing completion, the "Z-IX." They were, in the order of construction, "Z-II" (17,800 cubic meters), "Viktoria-Luise" (18,700 cubic meters), "Z-III" (17,500 cubic meters), "Hansa" (18,700 cubic meters), "Z-IV," which came down at Luneville (19,500 cubic meters), "Sachsen" (19,500 cubic meters), "Z-I" ("Ersatz II") (19,500 cubic meters), "Z-V" (19,500 cubic meters), "Z-VI" (19,500 cubic meters), "Z-VII" (22,000 cubic meters), "Z-VIII" (22,000 cubic meters), "L-3" (27,000 cubic meters), and "Z-IX" (22,000 cubic meters). The "Hansa" and "Viktoria-Luise" were all passenger-carrying airships belonging to the Delag Company, and the "Sachsen," their sister ship, had gone over to the navy in May, 1914. "L-3" belonged to the navy, the others to the army.

We can here add the "Schütte-Lanz," called "SL-2," of 22,000 cubic meters capacity, which had equaled the Zeppelins at the trials. We need not count two dirigibles, "M-4" and "M-1," and three non-rigid Parsevals, "P-4," "P-3," "P-2." The largest "M" is 13,000 cubic meters and the biggest Parseval 10,000 cubic meters, so that they simply do not exist as regards the cruise we have in view.

This gives us, therefore, fourteen units at the declaration of war, of which two ("Z-II" and "Z-III") were quite out of date; two others (the "Viktoria" and the "Hansa") were equally unsuitable for the cruise we have in view, and besides very much the worse for wear. Five were of a type that was not suitable for so long a trip, but they may serve for bombarding frontier towns (these are "Z-IV," "Sachsen," "Z-I," "Z-V," and "Z-VI"), and finally four dirigibles of 22,000 cubic meters capacity ("Z-VII," "Z-VIII," "Z-IX," and "Schütte-Lanz 2"), and one of 27,000 cubic meters ("L-3"). These figures explain the material impossibility of every attack in August.

I can hardly believe that Count Zeppelin, a personal friend of the Kaiser, German-aeronautical-demi-god, will admit the rival "Schütte-Lanz" to his squadron. The "SL-2" was already exiled at Liegnitz in Silesia, where it went from Leipzig on May 12th. We can, therefore, without hesitation, eliminate from our calculations the "SL-2" and its sister ship, the "SL-3,"

30,000 cubic meters capacity, which was in course of construction at Mannheim in August, and there have been no more of them.

Since then, it is known from an infinity of sources, *and on this subject there can be no possible doubt*, the Zeppelin works have built a Zeppelin every three weeks. Those who are astonished at this figure should remember that in 1913 eight Zeppelins were constructed (Nos. 15 to 22), which works out at one every six weeks, and that in May, 1914, there were opened at Potsdam works intended to double the output of those at Friedrichshafen.

The Zeppelin works have, therefore, actually constructed eight or nine dirigibles of new type since the outbreak of war. This makes a grand total of twenty-two units, of which thirteen have a capacity of from 22,000 to 27,000 cubic meters, the other nine remaining as above.

How many of them have been destroyed, and of what capacity were those destroyed? It is possible to ascertain the *certain* destruction of five Zeppelins: two in Russia (Warsaw and Libau), one at Dusseldorf, one at Badonvillers, one at Friedrichshafen. It is *possible* that five others have also been destroyed: one at Metz, one at Cuxhaven, a second one at Friedrichshafen, and two seen by our aviators stranded in the Ardennes in the month of August. There are besides *probable* accidents in the interior of Germany. For the rest we have no certainty.

There remain, then, at the most seventeen Zeppelins, at least ten, and probably twelve to fifteen, and it is not possible to ascertain how many of these can be counted as modern types of 22,000 and 27,000 cubic meters capacity, and 156 to 158 meters in length.

It is possible to state the certain destruction of two of the thirteen indicated above, that at Badonvilliers ("Z-VIII") and the one in course of construction at Friedrichshafen. The crew of thirty of the first unit destroyed by the Russians indicates a third one as almost certain. There remain then at the most, eleven Zeppelins capable of undertaking the expedition in question, and at least six, say, generally speaking, eight or nine. We find, then, that there are in existence and suitable for the raid which formed the object of this study, six to eleven dirigibles of from 22,000 to 27,000 cubic meters capacity and of 156 to 158 meters length, 14.60 meters and 16.58 meters diameter, with four screws grouped in two pairs on two *nacelles* in the axis of the keel and with central cabin. They have a mean speed of 60 kilometers per hour and a maximum speed of 72 kilometers per hour, and can travel with a load of 600 to 1,000 kilogrammes of explosives at a height of from 1,500 to 2,000 meters, according to the weather. Here we have, then, all the figures of the great adventure.

There is nothing very dreadful in it, especially if we consider the material impossibility of grouping them from the start for a collective raid, the absolute impossibility for them of arriving together when starting from different points, as before stated, and the no less absolute impossibility of successive attacks, once the adversary has been warned by the first dropping of bombs.

Some Questions of Evolution*

The Present Position of Natural Selection Considered

In the Darwinian era studies on variation and heredity seemed significant, mainly as a means of approach to the problems of evolution. The post-Darwinians awoke once more to the profound interest that lies in the genetic composition and capacities of living things as they now are. They turned aside from general theories of evolution and their deductive application to special problems of descent in order to take up objective experiments on variation and heredity for their own sake. This was not due to any doubts concerning the reality of evolution or to any lack of interest in its problems. It was a policy of masterly inactivity deliberately adopted; for further discussion concerning the causes of evolution had clearly become futile until a more adequate and critical view of existing genetic phenomena had been gained. Investigators in genetics here followed precisely the same impulse that had actuated the embryologists; and they, too, reaped a rich harvest of new discoveries. Foremost among them stands the re-discovery of Mendel's long-forgotten law of heredity—a biological achievement of the first rank which in the year 1900 suddenly illuminated the obscurity in which students of heredity had been groping. Another towering landmark of progress is De Vries's great work on the mutation theory, published a year later, which marked almost as great a transformation in our views of variation and displayed the whole evolution problem in a new light. In the era that followed, the study of heredity quickly became not only an experimental but almost an exact science, fairly comparable to chemistry in its systematic employment of qualitative and quantitative analysis, synthesis, prediction and verification. More and more clearly it became evident that the phenomena of heredity are manifestations of definite mechanism in the living body. Microscopical studies on the germ-cells made known an important part of this mechanism and provided us with a simple mechanical explanation of Mendel's law. And suddenly, in the midst of all this, by a kaleidoscopic turn, the fundamental problem of organic evolution crystallizes before our eyes into a new form that seems to turn all our previous conceptions topsy-turvy.

To judge by its external aspects, individual development, like evolution, would seem to proceed from the simple to the complex; but is this true when we consider its inner or essential nature? The egg *appears* to the eye far simpler than the adult; yet genetic experiment seems continually to accumulate evidence that for each independent hereditary trait of the adult the egg contains a corresponding *something* (we know not what) that grows, divides and is transmitted by cell-division without loss of its specific character and independently of other somethings of like order. Thus arises what I will call the puzzle of the microcosm. Is the appearance of simplicity in the egg illusory? Is the hen's egg fundamentally as complex as the hen, and is development merely the transformation of one kind of complexity into another? Such is the ultimate question of ontogeny, which in one form or another has been debated by embryologists for more than two centuries. We still cannot answer it. If we attempt to do so, each replies according to the dictates of his individual temperament—that is to say, he resorts to some kind of symbolism; and he still remains free to choose that particular form which he finds most convenient, provided it does not stand in the way of practical efforts to advance our real knowledge through observation and experiment. Those who must have everything reduced to hard and fast formulas will no doubt find this rather disconcerting; but worse is to follow. Genetic research now confronts us with essentially the same question as applied to the evolutionary germ. The puzzle of the microcosm has become that of the macrocosm. Were the primitive forms of life really simpler than their apparently more complex descendants? Has organic evolution been from the simple to the complex, or only from one kind of complexity to another? May it even have been from the complex to the simple by successive losses of inhibiting factors which, as they disappear, set free qualities previously held in check? The last of these is the startling question that the president of the British Association propounds in his recent brilliant address at Melbourne, asking us seriously to open our minds to the inquiry: "Whether evolution can at all reasonably be represented as an unpacking of an original complex which contained within itself the whole range of complexity which living things exhibit?" This conception, manifestly, is nearly akin to the theory of pangenesis and individual development, as elaborated especially by De Vries and by Weismann. It inevitably recalls also, if less directly, Bonnet's vision of "palingenesis," which dates from the eighteenth century.

We should be grateful to those who help us open our minds; and Prof. Bateson, as is his wont, performs this difficult operation in so large and masterly a fashion as to command our lively admiration. It must be said of his picturesque and vigorous discussion that we are kept guessing how far we are expected to take it seriously, or at least literally. We have always a lurking suspicion that possibly his main purpose may after all be to remind us, by an object lesson, how far we still are from comprehending the nature and causes of evolution, and this suspicion is strengthened by the explicit statement in a subsequent address, that our knowledge of the nature of life is "altogether too slender to warrant speculation on these fundamental questions." Let us, however, assume that we are seriously asked to go further and to enter the *cul de sac* that Prof. Bateson so invitingly places in our way. Once within it, evidently, we are stalemated in respect to the origin and early history of life; but as to that, one form of total ignorance is perhaps as good as another, and we can still work out how the game has been played, even though we can never find out how the pieces were set up. But has the day so soon arrived when we must resign ourselves to such an ending? Are we prepared to stake so much upon the correctness of a single hypothesis of allelomorphism and dominance? This hypothesis—that of "presence and absence"—has undoubtedly been a potent instrument of investigation; but there are some competent students of genetics who seem to find it equally simple to formulate and analyze the phenomena by the use of a quite different hypothesis, and one that involves no such paradoxical consequences in respect to the nature of evolution. Are we not then invited to strain at a gnat and to swallow a camel?

But I pass over the technical basis of the conception in order to look more broadly at its theoretic superstructure. Is not this, once again, a kind of symbolism by which the endeavor is made to deal with a problem that is for the present out of our reach? Neither you nor I, I dare say, will hesitate to maintain that the primordial Amoeba (if we may so dub the earliest of our ancestors) embodied in some sense or other all the potentialities, for better or for worse, that are realized before us at this moment in the American Association for the Advancement of Science. But if we ask ourselves exactly what we mean by this we discover out total inability to answer in more intelligible terms. We cannot, it is true, even if we would, conquer the temptation now and then to spread the wings of our imagination in the thin atmosphere of these upper regions; and this is no doubt an excellent tonic for the cerebrum provided we cherish no illusions as to what we are about. No embryologist, for example, can help puzzling over what I have called the problem of the microcosm; but he should be perfectly well aware that in striving to picture to his imagination the organization of the egg, of the embryological germ, that is actually in his hands for observation and experiment, he is perilously near to the habitat of the mystic and the transcendentalist. The student of evolution is far over the frontier of that forbidden land, in any present attack upon the corresponding problem of the macrocosm.

Perhaps it would be the part of discretion to go no further. But the remarkable questions that Prof. Bateson has raised concerning the nature of evolution leave almost untouched the equally momentous problem as to what has guided its actual course. In approaching my close I shall be bold enough to venture a step in this direction, even one that will bring us upon the hazardous ground of organic adaptations and the theory of natural selection. I need not say that this subject is beset by intricate and baffling difficulties which have made it a veritable bone of contention among naturalists in recent years. In our attempts to meet them we have gone to some curious extremes. On the one hand, some naturalists have in effect abandoned the problem, cutting the Gordian knot with the conclusion that the power of adaptation is something given with organization itself and as such offers a riddle that is for the present insoluble. In another direction we find attempts to take the problem in flank—to restate it, to ignore it—sometimes, it would almost seem to argue it out of existence. It has been urged in a recent valuable work—by an author, I hasten to say, who fully accepts both the mechanistic philosophy and the principle of selection—that fitness is a reciprocal relation involving the environment no less than the organism. This is both a true and a suggestive thought; but does it not leave the naturalist floundering amid the same old quicksands? The historical problem with which he has to deal must be grappled at closer quarters. He is everywhere confronted with specific devices in the organism that must have arisen long after the conditions of environment to which they are adjusted. Animals that live in water are provided with gills. Were this all we could probably muddle along with the notion that gills are no more than lucky accidents. But we encounter a sticking point in the fact that gills are so often accompanied by a variety of ingenious devices, such as reservoirs, tubes, valves, pumps, strainers, scrubbing brushes and the like, that are obviously tributary to the main function of breathing. Given water, asks the naturalist, how has all this come into existence and been perfected? The question is an inevitable product of our common sense. The metaphysician, I think, is not he who asks but he who would suppress it.

Now, it is undoubtedly true than many adaptations, to cite Prof. Bateson once more, are "not in practice a very close fit." Even the eye, as Helmholtz long ago taught us, has some defects as an optical instrument; nevertheless, it enables us to see well enough to discern some food for reflection concerning adaptations among living things. And it is my impression that efforts to explain adaptations are likely to continue for the reason that naturalists as a body, perhaps influenced by Huxley's definition of science, have an obstinate habit of clinging to their common sense.

*Extracts from an address by Prof. Edmund B. Wilson, President of the American Association for the Advancement of Science, before the Association at Philadelphia, December 14th, 1914.

Influence of Radio-Active Earth on Plant Growth—I*

Facts Indicated by Practical Experiments

By H. H. Rusby, Dean of the College of Pharmacy, Columbia University

Up to the time of the discovery of radium, anthracite coal represented about the highest known degree of stored energy. Radium is now believed to embody 360,000 times the energy of anthracite coal. The energy of radium is, however, of a totally different kind from that of coal. The energy of coal and other ordinary substances is exerted by the atoms of which they are composed; that of radium by the separation of these atoms into smaller bodies and the liberation of the energy of these particles.

Two hundred pound plots of early cabbage and pumpkins. No cabbage destroyed by cutworms.

Leaves of pumpkins in central plot without R. A. F., scarcely reach to man's knees. Cabbage in foreground.

As a result of this great difference radium can perform work only of a totally different character from that performed by ordinary substances. It is the dream of the physicist to discover a method by which the energy of radium can be exerted without this dissolution of its atoms, the effect of which would be revolutionary in the mechanical world.

These particles, "emanations," as they are known, are spoken of as "rays," notwithstanding that they are in reality matter, or substance.[1] They are so light that, even after long periods, the radium that is losing them cannot be seen to have lost weight. They are so numerous that, although constantly given off in vast numbers, it is estimated that it would require 2,000 years to exhaust one half of these rays in a particle of radium, and there is no way known by which the radium can be made to cease losing them. These emanations will accumulate in substances into which they enter, especially water, and will later be given off therefrom as they are from the radium, but while the substance still contains them and is giving them off, it is said to be radio-active, and it possesses, for the time, the valuable properties of the radium itself. This is especially true of water, as applied in medicine or to plants. It is to be noted that such emanations are not radium itself and do not contain radium; neither does the substance in which they are held. On the other hand, radium enters into various combinations with acids and these compounds may be dissolved in water and other liquids. Such solutions are radio-active, like those containing the emanations, and give off the emanations, but they differ from them in that they actually contain the radium metal. The bromide and the chloride of radium are the soluble compounds most used, the sulphate the principal insoluble one.

The rays given off are of different kinds, exhibiting different phenomena, having different velocities, penetrating different substances and for different distances and producing different effects on the bodies which they attack. They are distinguished as alpha, beta and gamma rays.

Two hundred pound plot of pumpkins with foliage reaching nearly to man's waist.

Since the general nature of living animal and vegetable protoplasm is identical, the question of influencing plant growth by the action of radium was at once suggested. Could it be applied to field crops so as to produce an increased yield? Could it be applied to crops suffering from animal or vegetable parasites, so as to kill the latter, as it kills cancer in man? Or, would the crops suffer more from such an application than would their diseases? If the application were found beneficial, would the amount of radium required for the purpose render the operation unprofitable? Or, seeing that the activity of a particle of radium goes on for centuries without any apparent diminution, would a single application to the soil permanently increase its agricultural productivity?

Plant physiologists, all over the world, took up investigations bearing on these questions. As would naturally be expected, these early investigations were restricted to experiments in laboratories, greenhouses and gardens. In Europe, something has been done in experiments with field crops and orchards, but in this country no reports of extensive field trials have heretofore been made.

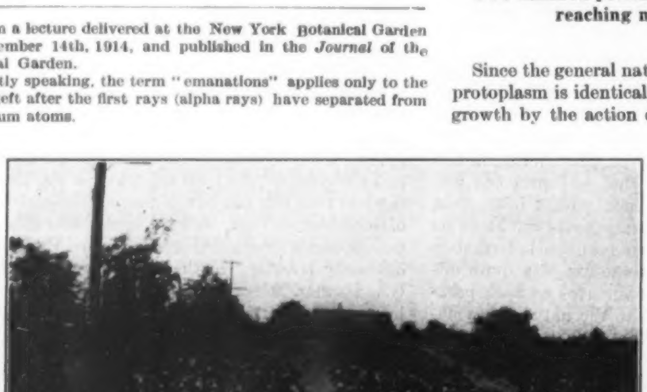
In October, 1913, I arranged with the Standard Chemical Company of Pittsburgh, Pa., to make preliminary trials on an extensive scale. In view of the cost of radium and its preparations, the reader may wonder how such an experiment could be undertaken. It requires about 400 tons of radium ore of standard quality to yield a gramme, about 15½ grains, of radium, which amount could easily be carried on a man's thumb nail. The regular market price is $10,000 a grain, or $120,000 a gramme, equal to $70,000,000 a pound. This problem was solved by making use of the finely powdered residue remaining after all the radium possible has been extracted, but leaving some two or three milligrammes to the ton, worth some $3,000, yet a by-product unless a special use for it could be discovered. Various other substances, especially uranium, are present in the material.

Before proceeding to describe these experiments and their results, it is desirable to briefly summarize the results of previous experimental work.

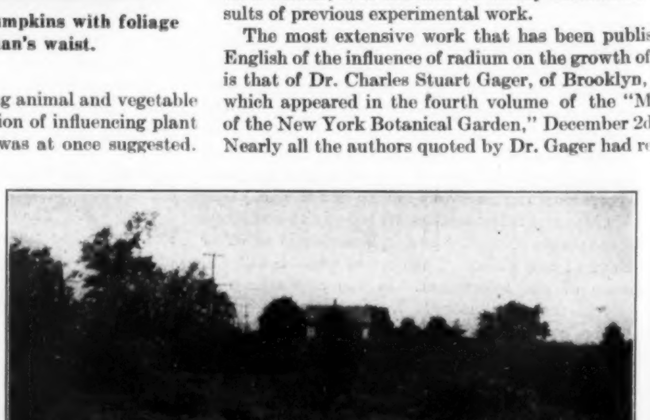
The most extensive work that has been published in English of the influence of radium on the growth of plants is that of Dr. Charles Stuart Gager, of Brooklyn, N. Y., which appeared in the fourth volume of the "Memoirs of the New York Botanical Garden," December 2d, 1908. Nearly all the authors quoted by Dr. Gager had reported

* From a lecture delivered at the New York Botanical Garden on November 14th, 1914, and published in the *Journal* of the Botanical Garden.

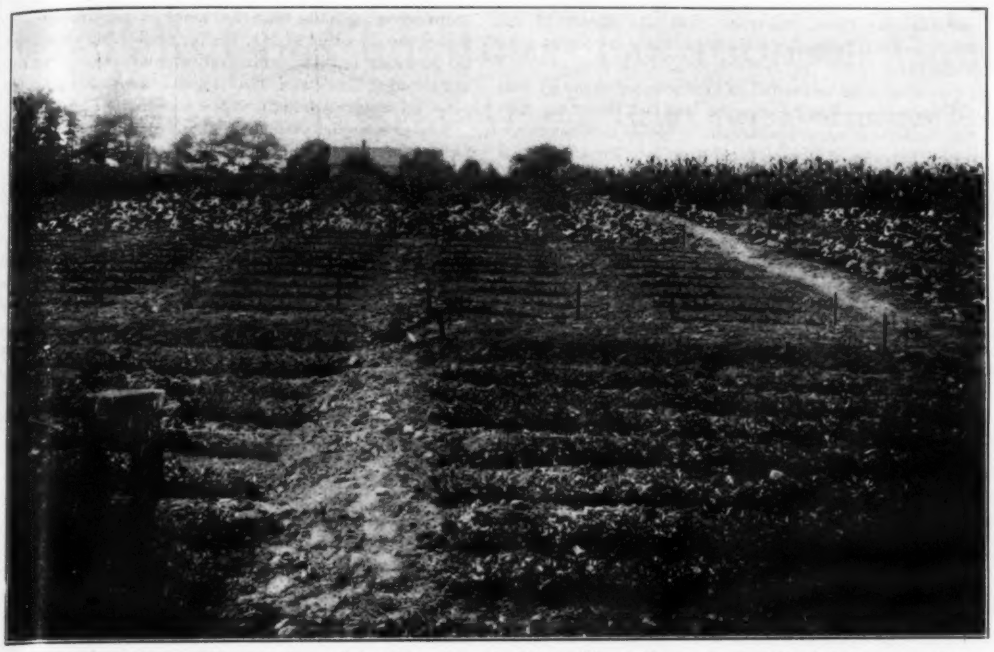
[1] Strictly speaking, the term "emanations" applies only to the residue left after the first rays (alpha rays) have separated from the radium atoms.



Globe turnips, two hundred pound plot at left, one hundred pound plot at right. Late celery in rear.



Celery at left stunted by excess of R. A. F.; left side of adjoining plot affected by emanations crossing path.



Celery in foreground; next, four plots of turnips, at right without R. A. F., but its left-hand portion favorably affected by emanations crossing path from twenty-five pound plot.

that the effect of radium was to retard or inhibit plant development, results which, as it will be here shown, were due to the use of enormously excessive quantities. Guilleminot had especially commented on the difference between the effects of low and high activities. He stated that while a certain low activity had no effect upon plants, the effect of from six to twelve times that amount would markedly retard growth, and from eighteen to seventy-two times would completely destroy. Yet he expressed the opinion that there was no strength that would positively stimulate growth. It was said that the distance at which the radium would act was limited to about 2 centimeters, less than an inch. Roots were found to be more susceptible than other parts of the plant. Some plants were more resistant than others and the turnip was mentioned as being especially so. Excessive branching of certain tissues was reported. It was found that parts of plants exposed to radium emanations would themselves become radio-active. The degrees of such radio-activity were, the root most, then, in order, stems, buds, leaves and flowers. It was decided that this activity did not exist in the tissues themselves but in their contained water.

Gager himself employed numerous methods of experimentation. He used tubes of glass and other substances which were coated on the inside with substances containing radium. He also used rods similarly coated on the outside. Such tubes or rods would be laid upon dry seeds for various periods of time and the seeds were then planted and their germination and growth compared with those of others not so treated. Seeds were soaked in water containing the emanations and were then planted and similarly compared. Plants were grown in water containing the emanations, while others, growing in the soil, were watered with such water. Plants were grown under bell jars in air that was kept charged with the emanations. Radium tubes and rods were buried in the soil in which seeds were planted. The radio-activities to which the seeds and plants were subjected in these experiments varied from 7,000 X up to 1,500,000 X, all of which, however, we now know were excessive. He always found the damage greater with the increase of activity. Similarly, he found that the seeds farthest away from the buried tube showed successively less injury. In short, it is seen that in every case of a change of conditions which resulted in a lower activity being exerted upon the seed or plant, the damage was less and he did not fail, as Guilleminot had done, to find strengths that would markedly stimulate germination and growth. He finally reached a conclusion expressed as follows: "*The rays of radium act as a stimulus to protoplasm. Retardation of growth following exposure to the rays is an expression of over-stimulation; acceleration of growth indicates stimulation between a minimum and an optimum point.*" He agreed that the root was more affected than the other parts of the plant, and his experiments show that members of the grass or grain family are more strongly influenced than others with which he experimented. He concluded that the gamma rays can penetrate as much as a foot in moist soil. As my own experiments show, they produce important effects at a distance of at least seven or eight times as great as this.

In France, Petit and Ancelin reported that by placing the seeds between sheets of blotting paper moistened with radio-active water, not only were a much larger number of ray-grass seeds germinated than when plain water was used, but the roots at the end of the thirteenth day were ten times as long as in the latter. With wheat and corn the increased length was not so great, but was very marked, as was also the greater length of the stems.

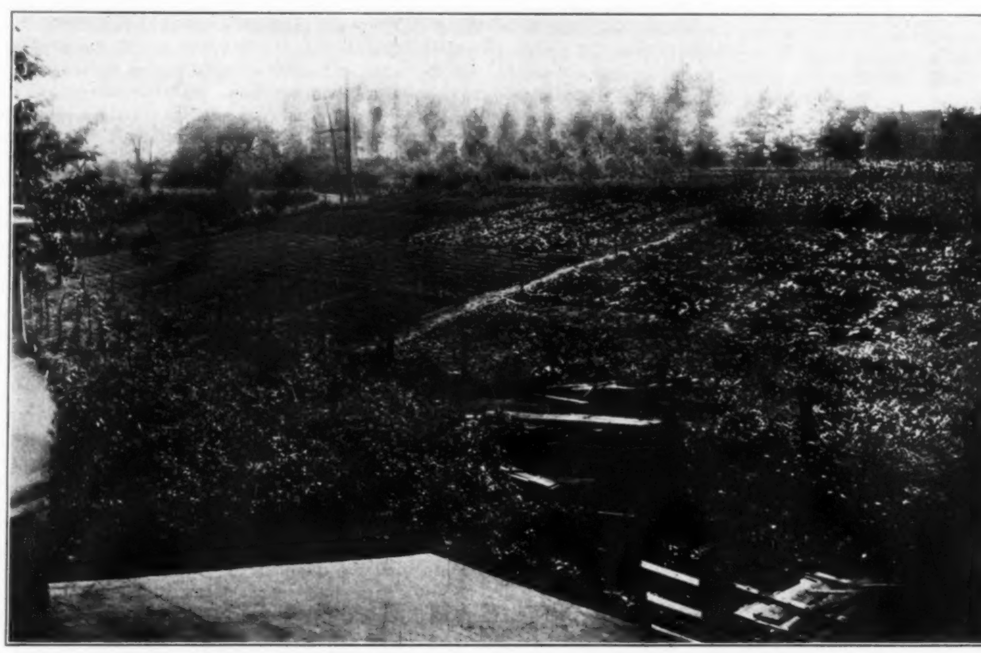
The National Agricultural School at Grignon, France, experimented with six varieties of potatoes and obtained by the use of radium an average gain of more than 16 per cent in the weight of the crop, the potatoes at the same time containing more starch and being correspondingly more mealy and palatable. Barley so treated gave 17.6 per cent more straw and 12.5 per cent more grain. Mustard gave 27 per cent more straw and 34 per cent more seed. Flax gave 24 per cent more straw and 6 per cent more seed. White vetch gave 19 per cent and fenugreek 11.5 per cent more fodder.

At the Agricultural School of Berthonval, the experiments were made on plots of a hectare each. Upward of a 15 per cent increase in the yield of grain was obtained by the radium treatment and over 14 per cent in that of sugar beets.

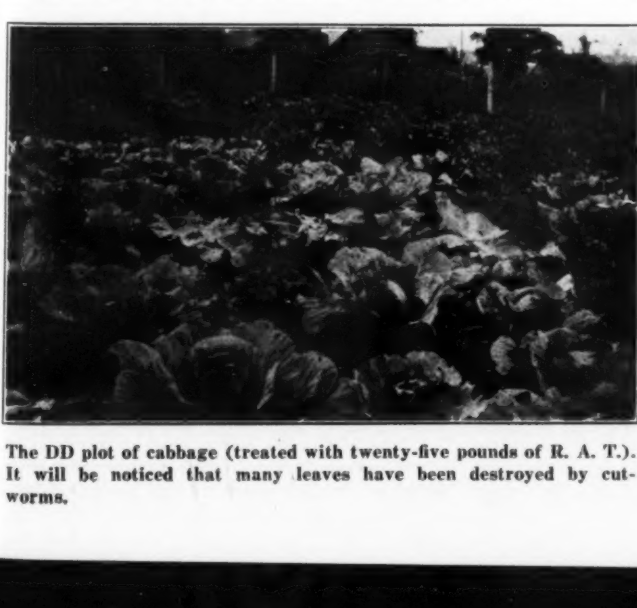
At the Harper-Adams Agricultural College at Newport, Foulkes also obtained a 14 per cent increase in the yield of table beets and more than 20 per cent in turnips, plots of a hectare each being employed.

Messrs. Vilmorin, Andrieux & Co. and others experimented with flowers, obtaining very satisfactory results on chrysanthemums, roses and other cut flowers.

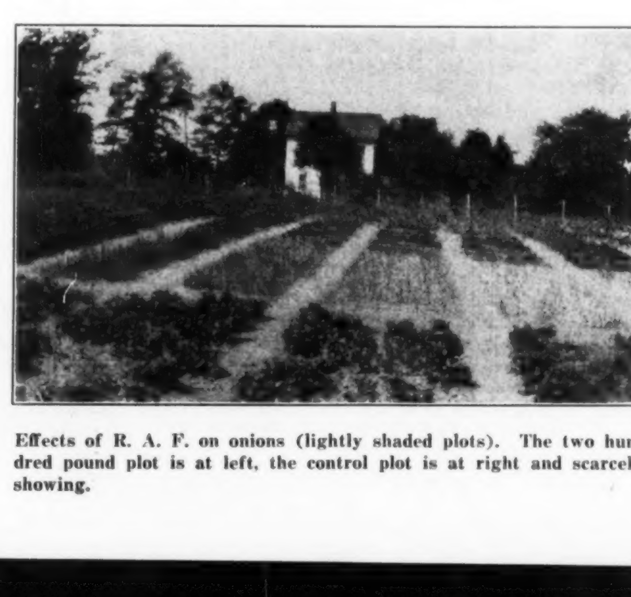
All experimenters with plants in pots have reported such phenomenal increases in root development that the plants quickly became root-bound and had to be successively



Southern half of northern half of farm, looking west from neighboring roof.



The DD plot of cabbage (treated with twenty-five pounds of R. A. T.). It will be noticed that many leaves have been destroyed by cut-worms.



Effects of R. A. F. on onions (lightly shaded plots). The two hundred pound plot is at left, the control plot is at right and scarcely showing.

transferred to other pots of a considerably larger size.

A most extensive series of experiments has been carried on at Joachimsthal by Dr. Julius Stocklasa, director of the Chem.-Phys. Institute at Prague. These experiments extended over a period of 7 years, the results being embodied in a voluminous report, made in September, 1913. There were many series of experiments. In one set, the plants were grown in ordinary soil and watered with water possessing various degrees of radio-activity. In another set they were grown in water supplied with plant food similarly charged, while in another set radio-active earth was employed. The following results were obtained:

The first experiments were directed toward ascertaining the effects of radium upon the activity of those bacteria which take nitrogen from the atmosphere and fix it in the soil in the form of plant food, thus enriching the soil. He found that liquids containing these bacteria gained from 32 per cent to 76 per cent more plant food in this way under radio-active influence than without it. Unused soil gained from 10 per cent to 30 per cent more fertility in a few months from this cause under the same conditions than without the radium.

Many previous experimenters had reported that radium exerted a toxic action on plant life, while others had declared to the contrary. Stocklasa repeated all these experiments, but in two series, one with very small amounts, the other with large amounts of the radium. He found that in most of the latter cases the effects were toxic, while in the former they were healthfully stimulating. He also found that different plants differed so materially in their susceptibility that the same amount of radium might be stimulant to one but toxic to another. What was even more interesting and important, he showed that families of plants manifested this difference.

When a very low radium activity was employed, the germination of seeds was increased from 70 per cent to 130 per cent, but it was retarded by a high activity. Drying and weighing two sets of plants after 48 days of growth, one set grown under radio-activity, the other not, the former showed an increase of over 200 per cent in peas, over 100 per cent in beans and lupines and nearly 900 per cent in barley. In another set of experiments, with lentils, peas and wheat, the gain by the use of radium ranged from 62 per cent to 158 per cent. With buckwheat, the increase ran from 42 per cent to 106 per cent. With poppies, there was an increase of 117 per cent in the seed, and 32 per cent in the plant exclusive of the seed, or 50 per cent in total. With lupines the seeds gained 64 per cent, the total gain being 60 per cent. The greatest gain was in the early stages of growth, the ratio decreasing thereafter.

These studies taught that all the main functions of the living cell are greatly stimulated by radium. The fact that starch production went on in darkness, and other corroborative facts, indicated that the effects of the radium closely resembled those of the ultra-violet rays of the sun.

Stocklasa also succeeded in synthetizing sugar by this radio-activity. The bearing of this fact upon the possible increase in sugar production by plants is momentous. It also explains the great increase in sweetness observed from the radium treatment of beets, carrots, tomatoes, pumpkins, squashes, melons, sweet corn and other vegetables. The fact that sugar-beets showed no increase in sugar content is perhaps due to their having reached a practical maximum in sugar production.

He summarizes as follows:

"All of our researches point to the fact that radium emanations with a low activity favorably influence the caryokinesis of the cell, the entire development of the plant, the mechanism of the metabolism, the photo-chemical assimilation in the chlorenchyma, bud formation and finally frutification. Emanations of too great activity exert an inhibiting influence on the growth of the plant and cause toxic symptoms in the cells, both in those containing chlorophyll and those without."

He also says that if we assume under ordinary conditions land will produce 200 hundredweights per hectare of corn or cattle turnips, we may expect 300 or 400 hundredweights under the influence of radium.

He concludes, finally, that the effects of radio-activity are greatest on young foliage and almost equally great on the petal tissues of the flower.

Against this array of positive evidence as to the stimulating effects of the radium, I had the negative effect of a caution from the French Agricultural Bureau against the probability of such a pronounced action as had been reported, on the ground that the amounts of radium in radio-active earths which had been employed were so very small. Little weight could be given to this suggestion, because of its purely speculative character. Although it was pointed out that ordinary farm soil is radio-active, often more strongly so than the radium mixture that was applied in the experiments, it was a pure assumption that this activity is wholly due to radium, or that such radium is actually present in the top-soil, and in fact it seems far more probable that it is in part due to the direct effect of the sun upon the soil. However, the case was one that called pre-eminently for the actual test of experimentation and to this I applied myself in the most practical possible way.

I made it my business for the time being, to ignore all theoretical considerations and to proceed with my trials precisely as a farmer would proceed in preparing the land and applying the radio-active material for a market crop.

My experiments and observations included the winter culture of radishes in a market gardener's greenhouse, some seedlings in window boxes in my own home; field crops covering more than 100 acres at Northfield, Ohio, under the direction of Mr. W. W. Darley, an experimental gardener at Pittsburgh, and the plantation of an acre and a half at Nutley, N. J., of which I have had immediate personal charge throughout the season.

The greenhouse radishes were already about an inch high when the radium was applied. A furrow was scratched midway between the rows, which were 4 inches apart, and the powder sowed therein at the rate of 10 grains to the square foot, which is equal to about 50 pounds to the acre. A square yard was thus treated and was compared with an exactly similar square yard upon the same bench, about 10 feet distant. The radium radishes soon appeared much inferior to the others, and continued to do so to the end of the experiment, the tops being smaller, as though stunted, but on harvesting and weighing the green tops and the roots separately, the tops were found to weigh 17 per cent less from the radium plot than from the other, while the radishes weighed about 20 per cent more.

The season of growth had been very bad, February being very stormy, with little sunshine, and that little largely excluded by snow lying upon the glass roof. This observation is of much importance, indicating that it required less green leaf surface under deficient sunlight for the plant to manufacture a larger amount of food for deposit in its root. It will later be seen that various other experiments indicate and elucidate this principle.

Both of my window boxes were filled from the same pile of soil, similarly treated in every way except that in one the above-mentioned amount of radium earth was mixed through the soil. All operations were conducted for both boxes at the same time. Their positions in the window were exchanged from time to time so as to preserve absolute equality of conditions. In the boxes I sowed cabbage and tomato seed in alternate rows. The seeds germinated one or two days earlier in the radium box and the plants were already well developed when those in the other box broke through the ground. The difference was more marked with the cabbages than with the tomatoes. The original lead of the radium plants continued to increase throughout the experiment, and after some two months, when the experiment was brought to a close, a given number of plants in the radium box would have weighed from six to ten times as much as from the other.

In Mr. Flannery's garden I particularly noted the great gain of turnips and beets under the radium influence over those without it. Radishes, which I did not myself see, were said to have yielded more than 100 per cent increase under the radium treatment. The quality of the radium-grown vegetables was a matter of special comment by all who tried them, and this has proved true of all vegetables raised elsewhere under this treatment.

(To be continued.)

Fuel Oil in the Navy

The following interesting facts are given in relation to the use of fuel oil in the United States Navy in the report on the production of petroleum in 1913 issued by the U. S. Geological Survey:

Tests have been carried out during the year at the fuel oil testing plant at Philadelphia with a view to making the naval specifications for fuel oil less strict in order to get an oil at a cheaper price.

During 1913 a board was constituted in the Navy Department to determine a proper flash point for fuel oils to be used on battleships. The importance of this subject has been recognized by reports from various experts to foreign governments, which have resulted in the adoption of the following minimum flash points for fuel oils for naval purposes:

Minimum flash points adopted for fuel oils for naval use.

	Deg. Fahr.
United States	*150
Great Britain	175
Germany	187
France	200
Russia	212
Italy	212
Austria	248

The board began its investigation by adopting the following assumptions:

(a) That oils having viscosities such that they must be heated in the bunkers must have such a flash point that no explosive or inflammable mixtures are formed therein.

(b) That it is undesirable and dangerous that oil should be heated anywhere—in bunkers or in firerooms—above the point where explosive or inflammable gases are given off.

(c) That the reliability of the flash cup in determining the point at which this condition of explosive mixture begins to exist should be checked in order that a guide may be established which may be known to be safe and positive.

*Reduced from 175 degrees by recommendation of this board.

The board then obtained large samples of oils which showed characteristics given in the accompanying table. These oils include the characteristics of practically all known fuel oils.

The first problem investigated by the board was to find the temperature at which various oils must be heated in the bunkers in order that the pumps may take more than the quantity for full-speed steaming conditions. With pumps such as used on battleships three grades of Mexican oils were used, those designated as 15.4 degrees, 17.3 degrees, and 11.7 degrees gravity Baumé, the last representing the extreme of viscous oils on the market. The suction was taken from the 1,200-gallon submerged oil tanks with about an 8-foot lift from about 100 feet of 3-inch piping bushed down to 2½ inches at the pump. The following results were obtained:

Pumping capacity of pumps for different oils at varying temperatures.

Temperature (deg. Fahr.)	Toltec, Mexican, 12 deg. Baumé, gallons per hour.	Mexican, 15.4 deg. Baumé, gallons per hour.	Mexican, 17.3 deg. Baumé, gallons per hour.
65	87	....	417
73	120	226	....
75	130	376	1,105
80	173	717	1,414
90	295	1,365	1,997
100	458	1,904	2,546
110	683	2,486	2,970
120	987	3,000	3,348
130	1,360	3,516	3,636
140	1,775	....	....
150	....	4,190	4,063

The board estimated that the standard Blake pump used in this test, which conforms with the installation on board ship, requires that this pump should deliver 564 gallons an hour, in order to secure an adequate quantity for full power. This, then, is taken as the standard of comparison in determining the temperature to which oil must be heated in order that the suction pumps may supply an adequate quantity for full speed.

It will be seen that the 17.3 degrees Mexican oil must have a temperature of 67 deg. Fahr. or above in order that the pump may take an adequate supply for full speed; the Mexican 15.4 degrees, a temperature of 77 deg. Fahr. or above; and the Toltec (Mexican) 12 deg. Baumé must be heated to 105 deg. Fahr. This latter result is considered by the board as the limiting temperature. The board ascertained that it is the practice on the Southern Pacific steamers burning this oil to heat up to 115 deg. or 120 deg. Fahr.

The next problem was to sample and analyze and attempt to ignite the gases given off in the bunkers at these temperatures, in order to ascertain the danger of such heating of oil in the bunkers. The investigation showed that no inflammable gas is formed under conditions similar to those in the bunkers of ships until the oil is heated to its flash point, and that the Abel Pennsky-Martin closed flash cup gives results which check with the results obtained in the tank. The experiment showed that the fuel oils in this experiment did not contain dissolved gas or vapor sufficient to form any explosive mixture until a temperature equivalent to flash point was reached. Examination of the air over the fuel oils in the bunkers of various battleships showed that this air did not contain more than an insignificant quantity of combustible vapor. Almost 0.9 per cent of combustible vapor must be present in a mixture of vapor and air to form an explosive mixture. The largest amount found was 0.04 per cent. The following conclusions were reached:

1. At the flash temperatures the vapors produced constitute about 1.0 to 1.25 per cent of the mixture of air and vapor. They consist principally of vapors of the liquid paraffins, hexane, and heptane.

2. On board ship these oils can be heated to within about 15 deg. Cent. (59 deg. Fahr.), of their flash point before even a noticeable halo or partial burning occurs should they be accidentally inflamed.

3. The flash points shown herein are a good indication of the temperatures to which the oils can be heated before an explosion of the released vapors can occur.

Effect of Climate on Location of Manufacturing Plants*

An Important Factor That Often Determines Economic Success

By William M. Booth

BEFORE discussing the location of a plant, let us divide manufacturing industries into groups respecting the source of raw materials or their equivalent.

1. Those that are compelled to locate near the source of the raw material, such as lumber mills, flour mills, cotton gins, sugar cane mills, beet sugar factories, cement plants, quarries, cheese, butter and condensed milk factories, canning factories and meat packing houses.

2. Those that must locate at or near a natural source of power, such as plants producing electricity from water power.

3. Plants, the location of which is fixed by fuel supply; coke production, steel and iron furnaces.

4. Good market locations; foundries and machine shops, clothing manufacturing, all articles of household use, water and gas plants.

5. Plants, the location of which is determined by climate: cotton and silk carding and spinning, and linen weaving.

6. Industries, the sites of which should be chosen; as agricultural implements, automobiles, cotton and woolen manufacturing, boots and shoes, brass products, smelting and refining, carriage and wagon factories, chemical manufacturing, knit goods, leather and paint plants.

For the latter, No. 6, fuel and raw materials may be shipped hundreds of miles if the related conditions are favorable. A careful analysis of the factors of location should be made for this class.

The shipment of fuel, stock and finished products places the manufacturer at the mercy of the transportation companies. Our northern climate absolutely prevents the continuous use of inland water ways for from three to eight months annually. To avail himself of cheap water freight rates, the manufacturer must move a year's supply of fuel or stock during the short navigation season. What is gained in a low rate is often more than outbalanced by interest charges on materials which must be protected by insurance in a warehouse. The railroad more nearly approximates a perfect system of transportation. This, however, is also subject to the vagaries of climate throughout our main manufacturing belt.

All classes of manufacturing in central and northern New York suffer annually from lack of fuel supply during January and February. Stalling of raw stock and frequent passenger and freight demoralization north of a line connecting Portsmouth, N. H., Pittsfield, Mass., Troy, N. Y., passing through Utica, Rochester, Buffalo, Detroit and Milwaukee, is not uncommon. In this region, shipments are lost in snow drifts and passenger service is sometimes suspended.

All power plants suffer from low temperatures. Water ways accumulate anchor ice that is difficult to handle and frozen water mains cause hours of delay and require many dollars to repair. Water, steam and soil pipes are necessary in every industry. The further north the location, the greater the annoyance and expense incident to frost.

Being no respecter of persons or things, gas is not exempt from the ravages of cold weather. In a northern city, a main of considerable size was carried over a bridge through a boxed conduit packed with horse dung. During a spell of extremely cold weather, I found the candle power of the gas lowered from 14 to 9 at this crossing.

I do not know of an instance where the extreme heat of our northern summer has any marked effect upon the mechanical equipment of railroads or the power plants of mills. Labor, however, responds quickly to climatic changes. During July and August, the cities in our manufacturing belt are subject to about three weeks of what is termed "close" "hot" weather. Many plants give employees an enforced vacation and take advantage of this time for the annual "clean up" and the necessary repairs. When the temperature reaches 80 deg. Fahr. in Central New York with extreme humidity, the average workman is incapable of much effort, either physical or mental. The mercury sometimes steadily climbs by night and day until it reaches the 100 degree mark. Factory discipline is demoralized, all are nervous, irritable, tired and cross. Production suffers accordingly, unless there are many automatic machines. Men in foundries, before furnaces and ovens and in closed areas, caring for special apparatus accustom themselves to great heat, and dress accordingly.

Mill locations are sometimes low, compared with the surrounding country. Extended areas of this character are often covered by fog from 4 until 8 o'clock A. M. during periods of high humidity and cool nights. Summer colds become epidemic from damp rooms and air.

Severe snow or rain storms are shown on the time clock records by tardiness and absence. Such may occur when orders are abundant and help is scarce or when a special order must be finished by a certain time. Severe and inclement weather over a period of several days sometimes demoralizes a northern mill where women are employed. Uniformly bad weather compels operatives to live but a short distance from the plant, which is usually a disadvantage from a home standpoint.

Considering extremes of heat and cold, white labor seems best qualified by temperament to work in the isothermal belt bounded by the 45th and 50th deg. Fahr. lines. Intensive miscellaneous manufacturing cannot thrive in the areas south of this because white help cannot work the year around in closed rooms at the high temperatures found south of Baltimore. The indifference of labor in the so-called "black belt" of the extreme south is one of the greatest handicaps to the manufacturer who builds a plant where extremely cheap labor abounds. Besides picking cotton in the open, the colored man has little value in the skilled labor market.

I see no reason why intensive manufacturing cannot be carried on in Washington State and Oregon, as soon as labor and market conditions warrant such activities. The humidity is sufficiently high in Portland and Seattle for textile mills. White employees can be utilized, for the 45-50 deg. Fahr. isothermal of the east also includes these localities. California must depend very largely in this particular upon Asiatic races now employed in the fields,—Hindoos, Chinamen, Japanese and Malays. Parts of Texas, Arkansas, Colorado and Utah are sufficiently elevated to attract white labor in mills during the greater portion of the year.

Atlanta has such an elevation as to place it in a temperature class considerably further north—about 3 deg. Fahr. In the east, all locations are greatly favored by a medium altitude. There are many mining camps in the United States, however, the elevation of which is sufficiently great to seriously affect the workmen. Those with weak hearts cannot be employed and the extreme dryness of the air cracks the lips, face and hands. The body tires easily and a heavy day's work is absolutely out of the question. At some altitudes, women cannot be employed, due to their sex.

It may seem unnecessary to mention the effect of sunshine upon labor. This is, however, an important consideration as the mind is more free and the body alert during a bright day than on a dark or cloudy one.

Machinery is ordinarily free from atmospheric changes. However, warm weather loosens belts and lowers the percentage of product. I have timed a machine, turning out 8,000 pieces per hour, and have found a difference of 600 pieces, due to irregular belt slipping.

We now come to the most important feature of our subject to the manufacturing chemist. I refer to apparatus and process work. My attention was first called to this in testing out a milk drying machine at an altitude of 1,100 feet. Neither thermometer nor barometer satisfied the conditions imposed. We finally settled the difficulty by reducing directions to changed altitude and succeeded fairly well.

In the manufacture of gelatine capsules, small cone-shaped forms are dipped into liquid gelatine. These pass out of the fluid, are elevated and dried by a current of warm air. This must be dry, and should be kept uniformly so by a conditioning process. One of the most hygroscopic substances with which I am acquainted is glucose. This has many uses and will absorb enough water to spoil other bodies with which it is mixed if the air is humid; equally difficult to manage is dry malt. Flour must be barreled and starch must be boxed in a dry room. Glycerine is very hygroscopic. Calcium chloride and caustic soda should be handled in very cold or dry air. Chloride of gold cannot be bottled on very moist days. Dry laundry chemical mixtures should be mixed and bottled or boxed in a dry atmosphere to prevent caking.

On the other hand, linen, cotton, jute and hemp must be spun and woven in very moist air. Many thousands of dollars have been lost by erecting a textile plant in a locality where the air is too dry. Fall River, Providence, Lawrence and Lowell owe their being to a moist (75 per cent humidity) air, with fairly uniform temperature, favorable to cotton spinning. Cotton manufacture has failed in dry air localities; it flourishes in moist air. The city of Denver was chosen for cotton mills and the experiment tried but partially failed because of lack of moisture. Small steel metal parts must be made in a reasonably dry climate. The enameled leather business is dependent upon sunshine. I have known a plant practically closed, waiting for a sunshiny day, that the leather might be banked in the open air, facing the sun.

When a superintendent tells me that climate has no effect on his output, I know he has not made a study of his conditions. I have never yet been in a mill where climate does not exact a penalty due to the carelessness or ignorance of the management. The finished product is no exception to the exactions of temperature. Food products and aqueous solutions must not freeze; japanned articles must not be chilled; metal parts must not be packed in damp material or stand in damp places in transit.

Northern mill owners and workmen are subject to a climate tax in the way of fuel, which may be estimated. In central New York, an industry employing 200 men and women burns three tons of coal for heating purposes exclusively, during each 24 hours of the winter months. This coal costs $3.00 per ton. Exhaust steam is not available as it is used for other purposes. The 200 employees represent about 60 families that burn on the average six tons of coal each annually for purely heating purposes. This costs $6.00 per ton; a total of about $4,000 for fuel due to a northern location in what may be considered a small industrial center in a country village!

To attempt to locate an industry where destructive wind storms are unknown would be impossible.

The annual floods of the Ohio and Mississippi valleys cause hundreds of thousands of dollars loss. Of this manufacturers pay their share.

The Allegheny mountains system contains many narrow valleys with steep sides that have been appropriated by manufacturers. Great loss occurs through the freshet season.

Syracuse users of Niagara electric current have occasionally been greatly inconvenienced by loss of power and light when feed wires are struck by lightning somewhere along the line. I understand that this difficulty is not uncommon where electric power is utilized and conveyed great distances at high voltage.

I have had two objects in view in the preparation and presentation of this paper. The first of these has been to unite certain data that have been collected by the weather bureau for various purposes and to apply these facts to the solution of the problems of plant location.

Having plotted an area that satisfies climatic conditions most favorably, this becomes one unit of a system of maps that may be superimposed, each of these representing the best location for an industry and covering the following:

Accessibility of raw materials, market, transportation, labor, power, water, supplies, climate, hygienic conditions, taxes, insurance, banking facilities, heating and lighting.

A practical manufacturing site can, for a given industry, be determined in this way in advance of the purchase of property or the erection of buildings.

The second object of this paper is to show that owners, superintendents and operators of manufacturing plants have seldom considered the various favorable and unfavorable effects of climatic change on the business in their charge, that many improvements may be made even in poor locations by heating, cooling, drying, filtering or adding moisture to the air of their rooms where operators work or where delicate processes are carried on.

*Abstract from a paper read by Wm. M. Booth before the Am. Institute of Chemical Engineers, and published in the *Transactions of the Society*.

A Handy Foundry Cupola

AT the Puget Sound Navy Yard, where the work did not warrant the regular operation of their foundry, there were frequent demands for a few small castings for quick delivery, and to make these by the regular foundry cupola of 6,000 pounds capacity entailed great waste and expense. To meet the difficulty a little cupola of 600 pounds capacity was constructed out of discarded material picked up around the shops which has done excellent work and proved very satisfactory. It is only about 4 feet high from the base, and the internal diameter inside the lining is 14 inches. The tuyeres, two in number, are rectangular in shape, and expanding, with their lower edges 10 inches from the bottom. The opening is 6½ inches wide at the broad end and about 5 inches at the narrow end by 4 inches deep. The ratio of cupola area to tuyere area is approximately three to one. The bottom plate is a casting incorporating the spout; the cylinder is made of steel plate. The blast is taken from the compressed air system of the yard. It induces air in a three-stage injector and delivers it to the cupola about fifteen times its own volume.

Photographing Projectiles—II*

By Means of Illumination from Electric Sparks

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2047, Page 205, March 27th, 1915

FIG. 15 is an old Mauser bullet in flight. The impressions of the rifling are plainly visible in the lead bands. The point of discharge of the electric spark is behind the projectile.

Fig. 16 represents the same bullet; the point of discharge of the spark is at the lower side of the bullet. Upon the head of the bullet straight lines were drawn and numbered. From the sharpness of definition of these marks in the photograph, it is to be inferred that it is feasible, by taking two photographs of the same bullet, at the beginning and at the end of a measured distance, and employing a method for discharging the sparks not readily disturbed by the motion of the projectile, to measure the number of turns with very satisfactory accuracy.

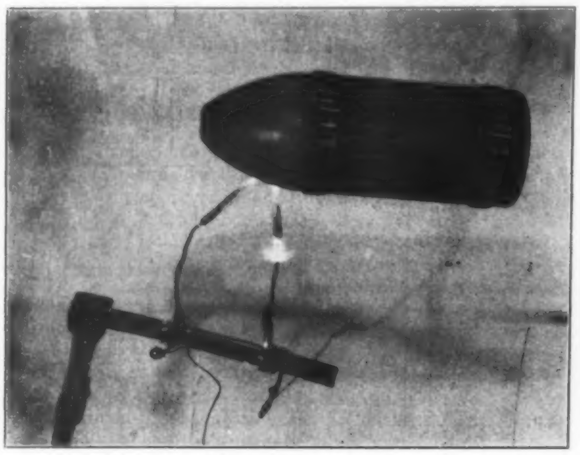


Fig. 15.

Fig. 17.

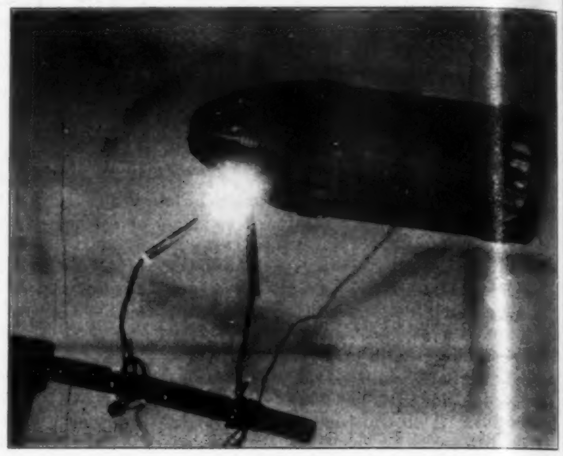


Fig. 16.

Fig. 17 is the infantry bullet in flight at a distance of about 2 meters from the muzzle. The impressions of the rifling are plainly visible in the negative. We are thus in a position to ascertain whether the projectile follows the rifling or not. The picture shows, besides the bullet in flight, one of similar characteristics at rest. Comparing the length of the bullet in flight with that of the one at rest, we are in a position, the velocity of the bullet and its true length being known, to determine the length of time required for making the image on the plate in lighting by means of the electric spark, or at least to obtain a superior limit for the lighting interval. This determination naturally applies only to the special conditions under which the photograph was made; that is to say, for a spark light of definite capacity and length of spark diffusely reflected and passing through a lens. Two separate determinations gave the following values: for a capacity of 45,000 the lighting interval was 0.4 millionth of a second; for a capacity of 3,500 and another projectile the lighting interval was from 0.19 to 0.13 millionth of a second. For the latter figure the details were as follows: lengthening of the picture, determined by a projection apparatus and Zeis scale, 16.1−16.0=0.10 centimeter; photographic reduction, 1.735 to 1; that is to say, the apparent lengthening of the projectile is to be multiplied by 1.735 millimeter to determine its true value. The velocity of flight is 890 meter-seconds; and the lighting interval is $\frac{0.1735}{1000 \times 890} = 0.19$ millionth of a second; by measuring the same negative with a microscope the interval is found to be 0.13 millionth of a second.

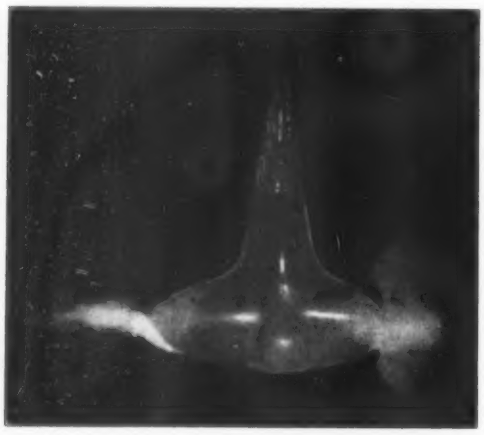


Fig. 19.

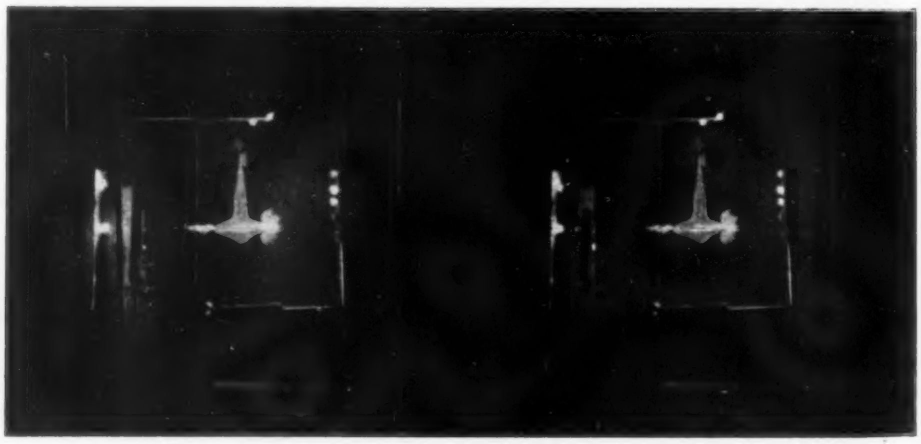


Fig. 20.

Fig. 21.

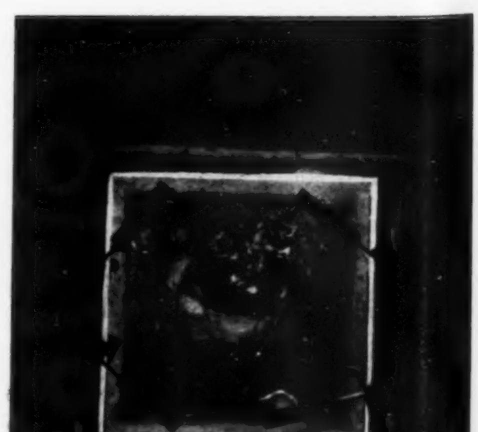


Fig. 22.

Fig. 18 shows the dial of a Hipp's clock, with two exposures on the same negative, while the clock was going. The first illumination was effected by means of a projectile of Model 88, completing, in its flight, an electric circuit by connecting two sheets of tinfoil near the muzzle of the gun; and the second illumination occurred when the same projectile after a further travel of 45.48 meters connected two other sheets of tin-foil. The time of flight of the Model 88 bullet and the mean velocity may now be determined as follows: The long hand has passed across the graduation mark numbered 45. One edge of the small hand has in the same time advanced from 79.6 through the zero to the position 52.6 (the readings should be obtained by enlarging the negative with a projecting apparatus, when the figures after the decimal point cannot be in error more than a single unit). The two readings of the clock are then 4479.6 and 4552.6, and the time of flight is 4.5526 − 4.4796=0.0730 second, according to Hipp's clock. The test of the Hipp's clock

* By C. Cranz, P. A. Günther, Captain, 49 thRegimen, Field Artillery, and F. Külp, Captain, 118th Regiment Infantry. Translated from the *Zeitschrift für das Gesamte Schiess-und Sprengstoffwesen* for the *Journal of the United States Artillery* by Charles A. Junken.

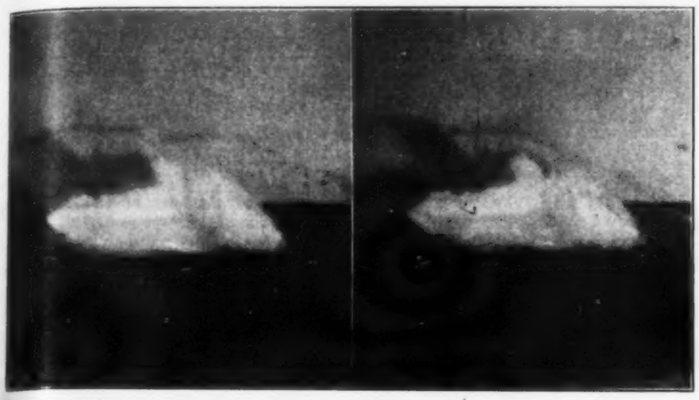


Fig. 23.

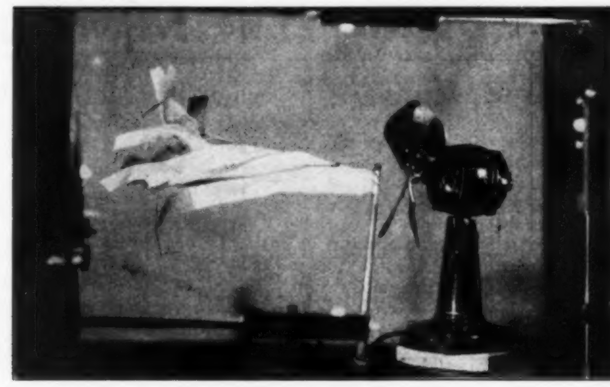


Fig. 24.

by means of an ordinary clock showed that 20 seconds true time was 20.085 seconds by the Hipp's clock. The time of flight of the projectile in true time is, therefore, $0.073 \times \frac{20}{20.085} = 0.727$ second. The measured travel being 45.58 meters, the mean velocity is $45.58 \div 0.0727 = V_{25} = 627.0$ meter-seconds. According to A. Burgsdorff

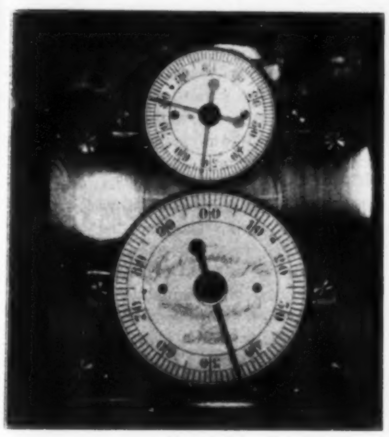


Fig. 18.

the mean velocity of the bullet Model 88, is $V_{s} = 640$ meter-seconds; while the mean velocity of the same bullet determined at an earlier date in the Ballistic Laboratory was $V_{25} = 624.7$ to 627.0 meter-seconds. We may therefore conclude that the deduced value, $V_{25} = 627.0$ meter-seconds, is thoroughly established for this individual bullet by the several methods of determination. But it is far from our intention to substitute for the established practice a new method of measuring the velocities of projectiles; it is better to restrict the method to laboratory use exclusively.

Fig. 19 shows the bursting effect of the S-bullet in perforating a freely suspended rubber bulb filled with water. The bullet has perforated the rubber bulb and is passing out of the field of view to the left. The rubber covering has been sharply distended in the direction of the projectile, and will subsequently be torn completely apart, the water being thrown in all directions. (The object of this and similar photographs is a reply to such questions as those asked us by the celebrated army surgeon Doctor von Bruns in regard to the ways and means by which the head of a bullet is deformed in perforating soft parts of the human body.)

Fig. 20 is a stereoscopic photograph of the same.

Figs. 21 and 22 show the explosive effect of the S-bullet on moist clay. Within a wooden box (Fig. 21) a ball of moist clay is placed in the line of fire; close behind the clay ball are the points of discharge of the electric sparks; the four illuminating spark-plugs are connected by short conductors with the condensers and discharged one after the other; they are visible at the four corners of the box. In Fig. 22 is shown the same clay ball as it appears shattered after perforation by the S-bullet, fragments being scattered in all directions, but remaining constant in volume. These fragments were thrown with great force against the walls of the box toward the gun and to the rear.

Fig. 23 is a stereoscopic photograph of a ricochet on the water.

Fig. 24 is a fan in rapid revolution. During the incredibly short period of illumination the fan appears stationary. That it is actually revolving is shown by its effect on the paper strips.

Fig. 25 shows falling drops of water. The phenomena well known to natural science concerning the separation into single drops of the steady stream and the periodical formation of the falling drops are actually reproduced in this photograph in an unusually clear way.

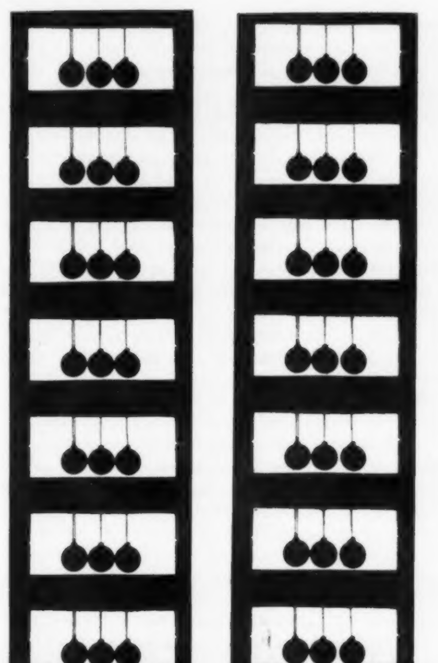


Fig. 27.

Fig. 26 shows the same phenomena for quicksilver from a small opening, under slight pressure.

Fig. 27 is moving-picture film made with a time interval of 1/5,000 of a second from picture to picture.

In order to illustrate the characteristic difference between kinetoscopic shadow pictures and kinetoscopic photographs lighted from the front, there is given in

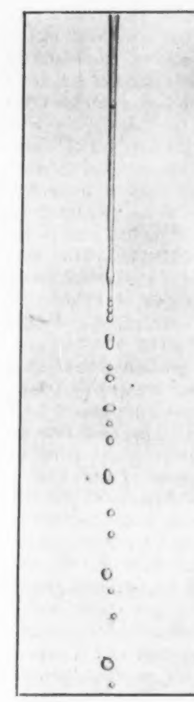


Fig. 25.

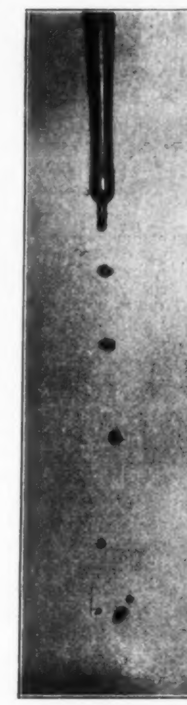


Fig. 26.

Fig. 27 a section of a moving picture film made with light from the background, that is to say a series of shadow photographs. Two steel balls are so suspended that when they are at rest they lie close together. A third ball swings from the left and strikes against the first ball at rest. After the blow, the first, or middle, ball remains at rest, even after the full stroke; the second ball formerly at rest swings off to the right. The whole film, which consists of 300 pictures, was obtained with concave mirror and objective by Mach's characteristic methods. One picture follows the other at the rate of 1/2,500 second. Such serial shadow pictures are comparatively easy to obtain with the ballistic kinetoscope of the laboratory where is obtainable sufficient light, shining directly from the rear, past the balls, and falling on the objective lens of the camera. It is vastly more difficult, however, to obtain such serial negatives with the ballistic kinetoscopic methods in common use, employing frontal illumination; that is, using the light reflected into the object lens of the camera from the face of the object to be photographed. It is practicable to obtain such pictures of a moving object at all only by intensely concentrating the electric spark light.

The Harmful Constituents of Roasted Coffee (Coffee-Toxin)

THE disturbances of the digestion which follow excessive coffee drinking are considered by the author, in a communication to the Société de Therapeutique, not to be due in any degree to the caffeine, but solely to certain volatile constituents formed, and only partly volatilized, during roasting. These are named cafeotoxin, and may be eliminated by submitting the roasted coffee to successive treatment with steam under pressure of several atmospheres, following by exposure under a vacuum. The coffee thus treated is called "atoxicafe." It retains its caffeine unaltered. It differs from ordinary coffee only in containing less cafeotoxin. Cafeotoxin has a marked reducing action on haemoglobin, a hypotensive action on the circulation, a depressant action on the central nervous system, occasioning cardiac arhythmia, and on the respiratory centers, causing dyspnoea.—*Pacific Phar.*

The New Knowledge of Coal Tar*

Scientific Methods for Utilizing the Products of Coal

By Horace C. Porter

THE INDUSTRIAL IMPORTANCE OF COAL.

THE question may be asked: Why should a chemical-engineering course begin with a lecture on coal? Is the efficient use of coal a fundamental thing in engineering?

Unquestionably power production stands as one of the foundation stones in the structure of any industry, and of the total power which operates modern industries at least 80 per cent is derived from the combustion of fuel, a chemical process. Coal and coke and gas made from it constitute 85 per cent of the industrial fuel of America.

Proportionate cost of power varies widely in the different industries, but taking them as a whole, census reports show that fuel constitutes about 8 per cent of the operating costs (exclusive of the cost of materials) in manufacturing industries. The importance of efficiency in the use of fuel becomes at once apparent. Over 150,000,000 tons of coal are used for industrial power. If the percentage utilization of the energy of this coal were everywhere increased by 8 per cent, an increase entirely possible through the use of modern, improved, steam engineering appliances and of the gas producer and gas engine, the cost of the industrial fuel used in the United States would be cut in two, and at least $150,000,000 saved. If all the coke produced in the United States in 1913 had been made in by-product ovens, $80,000,000 worth of by-products might have been saved and $10,000,000 in higher yield of coke.

Coal is by far the biggest mineral product of the United States. The production in 1913 was about 570,000,000 tons and the bulk of this was consumed in our own land. The nation's coal bill was, therefore, in the neighborhood of 1½ billions of dollars, or $60 for each wage-earner per annum. The United States is far ahead of other nations in coal production, having passed Great Britain, the nearest competitor, in 1899, and now surpassing her by nearly 100 per cent. Since we export very little coal and other nations export a great deal, our home consumption surpasses that of other countries by even a much greater margin. Our industries are greater, to be sure, but we must face the fact also that an abundance of fuel resources has made us careless of efficiency in their use.

The coal reserves of this country are immense, the most recent estimates of the United States Geological Survey (for the XII International Congress of Geology, Canada, 1913) showing 1,500 billions of tons easily available, not including the sub-bituminous and lignitic coals, these being not widely used now. If production should increase in the future at the rate it has in recent years, the exhaustion of our high-grade reserves may come at no very distant day. But unquestionably there will be a tendency toward a lesser rate of increase in consumption as the present movement toward greater efficiency in the mining and use of coal gains headway and brings results.

We may inquire somewhat analytically: What are the uses of coal and in what way can they be made more efficient? The 570,000,000 tons produced in 1913 in the United States were used approximately as follows:

	Tons.
Domestic	120,000,000
Other heating of buildings	85,000,000
Coke and gas	75,000,000
Locomotives and steamboats	110,000,000
Industrial power (including central power plants)	180,000,000

Scientifically the methods of utilizing coal may be classified into (1) combustion, (2) carbonization, and (3) gasification by partial combustion. Probably 80 per cent of the coal consumption in America comes under class (1), i. e., it is burned in air directly, and we see therefore, the great importance of improving practical methods and appliances for combustion.

COMBUSTION.

When we analyze combustion as ordinarily carried out in practice we find all three of the fundamental processes going on. Coal does not burn as a whole on the furnace grate. The upper layers of the fuel bed undergo decomposition by destructive distillation, liberating 15 to 40 per cent of the coal as volatile gases and vapors, while combustion of the residual material is going on in the lower portions of the bed. Gasification of the carbon to carbon monoxide also constitutes an important part of the burning process, the fuel bed acting as a gas-producer.

Smoke prevention is essentially a problem of proper handling and thorough combustion of the volatile products of the coal; in fact, furnace efficiency is to an important degree dependent on the same factor. The successful and efficient operation of a coal-burning furnace requires an understanding of the nature and behavior of the volatile matter of coal, and especially of that of the particular coal that is used in each case. Something as to the new knowledge of the volatile matter of coal will be presented later, after other methods of utilizing coal have been considered briefly.

CARBONIZATION.

Carbonization, from the point of view of fuel efficiency, deserves a much greater industrial application than is now given it. It enters as a factor to be sure, into all the applications of coal, and in coke and gas manufacture it constitutes the essential factor. But only a small percentage of the coal produced goes into coke and gas manufacture.

In carbonization the coal is decomposed under the influence of heat, without access of air, and the entire substance other than the mineral constituents break down into volatile products and a fixed residue, principally carbon and ash. The volatile matter of the coal here again comes into play as an exceedingly important phase of the process. The manner of the first breaking down of the coal substance as it begins to be heated probably determines in large measure what quality of coke any coal will form. The early or primary volatile products and the kind of heat treatment they receive as they issue from the retort determine the gas and by-product yield of the coal.

Instead of carbonizing and burning in a single operation as is done in a combustion furnace using coal, whereby all of the coal and the intermediate products evolved from it are burned for their heating value only, the coke oven or gas retort utilizes the coal more scientifically by converting it into two improved forms of fuel—coke and gas—with a combined heating value about 85 per cent of that of the coal, and in addition thereto saving the intermediate by-products—tar, benzol, and ammonia—which have a chemical value far exceeding their fuel value. The coke and gas can be burned as fuels without smoke and with greater efficiency than the raw coal. A portion of the coke or o the gas, to be sure, must be used to supply the heat for carbonizing, this item amounting usually to from 10 to 14 per cent of the original heat units in the coal.

It is not an idle dream to look forward to the time when there will be many central power and heating stations in the form of large by-product coke-oven plants, placed at the mines or near large cities. As influences leading to this end, we may mention the following: modern advances in long-distance transmission of electric power, the increasing demand for and value of coal by-products for chemical purposes, the successful use of coke as a domestic and industrial fuel, the development of the gas engine, and the growth of public opposition to the smoke nuisance.

Low-temperature or medium-temperature carbonization of coal has lately been introduced in Europe on an industrial scale. Coal is heated at 500 deg. to 700 deg. Cent. either under reduced pressure or in a current of auxiliary gas which passes directly through the coal, producing high yields of tars or oils and rich gas in small quantity. These processes depend for their commercial success on the quality of and the demand for the oils and the solid residues produced. Because of their adaptability to the recovery of oils, possibly motor fuels, from coals not heretofore commonly used for by-products, they offer an interesting field for industrial experiment in the United States. In the present commercial situation brought on by the European war the lack of an adequate supply of creosote oil, largely a coal-tar product, is a big incentive to the increase of coal-carbonizing operations in this country. Sufficient coal tar and benzol can be produced from existing by-product coke ovens and gas retorts to supply the present American demand for all other coal-tar products, creosote oil being excepted. But in view of the increasing use of benzol for many purposes and of the growing demand for coal-tar products of all kinds, there is an opportunity for a large expansion of the coal-carbonizing industry in the near future.

GASIFICATION BY PARTIAL COMBUSTION.

The third general method by which coal is used industrially is exemplified in the gas-producer, comparatively a very efficient method of recovering the potential energy of the fuel. Carbonization enters into this process also, since at the top of the fuel bed the coal is destructively distilled before passing down to be gasified by the air and steam from below. The gas producer will be treated thoroughly in one of the succeeding lectures of this series.

Having considered the industrial uses of coal in a general way, we may, to advantage, take up now some of the scientific aspects of the problems and allude to some of the more recent findings in this field.

NATURE OF COAL.

It is of interest to inquire first: What is coal? What is its chemical nature and constitution? A knowledge of this would surely be of great value in promoting an understanding of its behavior; in determining, for example, the explanation of the coking property; the cause of spontaneous combustion, or the difference between coals in liability to dust-explosions in mines. Unfortunately, however, the problem has proven a most difficult one, and as a result of the work of many investigators during the last 20 years or more, little of a definite nature has been determined. We may say without hesitation that coal is a mixture of complex organic substances which are degradation products of cellulose, resins and gums, and vegetable fats and waxes. Free carbon has never been proven to exist in coal, and hydrocarbons are probably not present in an amount greater than 1 per cent.

The problem of the constitution of coal has been attacked chiefly by two methods: (1) Extraction with solvents, and (2) destructive distillation at low temperatures. Extraction, while it has resulted, by use of pyridine, in dissolving and removing 15 to 18 per cent of the coal substance, has not separated any single definite identifiable compound in more than mere traces.

Destructive distillation also has led to no exact results, but it has given, on the other hand, certain well-defined indications of the nature of the substances present. These indications are mainly that coal is made up of a great many complex substances, which have resulted from degradation or decay of plant cellulose, lignose, resins and waxes. These substances in coal are closely graded into one another in chemical nature and composition, except that the cellulose and lignose group is probably more or less sharply distinguished from the resinous group. Within each group are substances in many different stages of alteration by aging. Chemically the cellulose bodies are distinguished by their higher content of oxygen, by their tendency to combine with or absorb oxygen, and by their thermal decomposition into CO_2 and CO, water of constitution, and paraffin hydrocarbons. The resinous constituents, on the other hand, have a higher content of hydrogen, less of oxygen, and decompose by heat into hydrocarbons and hydrogen with small quantities of CO_2 and water. The resinous bodies are contained most abundantly in the coking and mature coals of the Appalachian region.

THE VOLATILE MATTER OF COAL.

The term "volatile matter of coal" is more or less of a misnomer, but serves as well as any other. There is probably little or no material in coal which is volatile without decomposition. What we call "volatile matter" is the mixture of vapors and gases resulting from decomposition of the coal substance by heat. Its composition depends on the kind of coal and also very much on the temperature to which the coal is heated and to which the primary products are subjected. By "primary products" are meant those which form first as the coal slowly rises in temperature. These are, in order of their formation: water, hydrogen sulphide, carbon dioxide, various saturated and unsaturated paraffin hydrocarbons and hydrogen. Many, in fact most, of the commonly known constituents of coal gas, coal tar and gas liquor, such as benzine, naphthalene, pitch and ammonia, are the products of secondary decomposition of these primary products.

The volatile products of coal are not all combustible. From some bituminous coals, completely dried, we obtain by decomposition as much as 10 per cent of non-combustible volatile matter, and from some lower-grade coals even as much as 15 or 18 per cent. So there can be no question that the term "volatile combustible matter" as frequently used is decidedly a misnomer, since from one-eighth to one-half of the volatile matter of coal is non-combustible. It is important to bear this in mind when comparing coals, since those coals having rich, smoky volatile matter are more difficult to burn efficiently than others having a volatile matter possibly greater in amount but containing a larger proportion of inert matter.

An organic substance, of the nature of cellulose, produces water and CO_2 (with CO also) on decomposition by heat. When cellulose itself decomposes at temperatures below 500 deg. Cent., 43 per cent of its weight

*Lecture delivered by permission of the Director of the U. S. Bureau of Mines, before the Department of Chemical Engineering, University of Pittsburgh.

appears as water and CO_2 in the volatilized products. So also coal produces these things by decomposition, and the more abundantly the less matured and metamorphosed is the coal. We must expect to find an aqueous liquor distilled from coal during its decomposition, and in fact at gas works and coke ovens such is the case, a much greater volume of aqueous ammonia liquor being obtained, especially in the hydraulic mains (the first condensing point), than corresponds to the volume of the wash water added.

These facts enable us to draw inferences, at least, as to the chemical character of some of the substances in coal. The younger coals, like the lignites and the sub-bituminous coals, must contain large proportions of bodies with —OH or —CHO groupings, like the celluloses, since they produce water and CO_2 so readily; in the more mature coals, like the coking and high grade steaming coals, there are not as many of these oxygen-bearing groups, but, probably, more of certain highly complex long-chain or many-ringed bodies having side-groups of readily separable hydrogen atoms or of alkyls corresponding to the paraffin and possibly the aromatic hydrocarbons. These hydrocarbon groups are set free by heat, and then easily undergo further decomposition into the simple, commonly known products like methane and hydrogen.

The theory of Wheeler (of the British Coal-Dust Experiment Station) and others, that coal contains considerable quantities of certain substances which decompose only above 700 deg. Cent. and yield principally thus hydrogen and the oxides of carbon, is hardly justified by the experimental data at hand. More reasonably is it to be supposed that the large amount of hydrogen produced above 700 deg Cent. comes from secondary breaking down of the hydrocarbons first liberated, and of the partially carbonized solid material left behind, these things not having been present, either of them, as such in the original coal. It is likely that all the organic substance in coal decomposes early by heat, below 500 deg. Cent.

The nature of the substances liberated or volatized from coal by moderate heat throws some light on the coking properties of the coal. If by prolonged heating at 400 deg. Cent. the coal shows little or no tendency to soften or sinter together, and liberates water and gas but only a small quantity of heavy, viscid tar or pitch, it has not good coking properties. Laboratory tests to show coking quality of coals have never been satisfactory. Several are used which give more or less indication but are not definite. Among these may be mentioned (1) heating to a red heat a small sample inclosed in a covered, well-filled platinum box, and examining the coke bar produced; (2) rubbing or grinding the coal in a mortar and noting the tendency to cake or adhere to the pestle and mortar; (3) analyzing for C, H and O and comparing ratios of O to H.

In recent laboratory experiments in Germany cellulose has been converted into coal by subjecting it to very great pressure with moderate heating.

Investigations are in progress at several places to determine methods of increasing yields of some of the by-products of coal carbonization, e. g., the commercially desirable benzol and light oils, through carbonization under carefully controlled conditions, of the tars thus produced.

RATE OF EVOLUTION OF VOLATILE MATTER.

In the utilization of coal, particularly in burning on furnace grates, the rate at which the volatile matter is set free is frequently of greater importance than the total quantity produced. Coals vary greatly in this respect. The following results obtained in the laboratory on three different coals similarly treated (0.4 gramme powdered, air-dry coal heated at 1,000 deg. Cent.) bring out this variation:

Time	5 seconds		80 seconds	
Per cent volatile matter		Total Combustible		Total Combustible
New River, W. Va., coal...	5.8	4.8	20.0	17.5
Pittsburgh, Pa., coal......	9.0	7.5	34.0	28.1
Sheridan, Wyo., coal......	36.0	12.4	49.0	21.6

It may be seen from these data that while the Pittsburgh coal produces finally more combustible volatile matter than the Wyoming, the latter on the other hand liberates considerably the more in the first few seconds of heating.

The rate at which a given coal liberates volatile matter depends (1) on its chemical character, i. e., its ease of decomposition; (2) on the rate at which heat is supplied to it. The ratio between the quantity of coal heated and the quantity of heat supplied in unit time determines the rate at which any given coal becomes heated. It is, therefore, not a question of temperature as much as of quantity of heat and quantity of coal. When each particle of coal has attained a temperature of 900 deg. Cent. its decomposition into coke and volatile matter is practically complete.

SUMMARY.

Three points stand out as of importance in connection with the volatile matter—the element which is so vital in all processes of coal utilization:

1—The composition as well as the quantity of volatile matter varies greatly among coals.

2—The first products volatilized in the early stages of a coal's rise in temperature are essentially different from the total product as usually obtained. These first primary products are largely tarry liquids, with some water vapor and heavy complex gases. Heating conditions determine the degree of secondary thermal decomposition of these products and the composition of the final gas and tar.

3—The rate of evolution of the volatile matter from coal is of practical importance and varies considerably with the kind of coal. For a given coal it is dependent upon the relation between the quantity of coal heated and the quantity of heat supplied—not the temperature.

OXIDATION, IGNITION, SPONTANEOUS COMBUSTION OF COAL.

Next to thermal decomposition or the evolution of volatile matter perhaps the most fundamental process involved in the practical utilization of coal is that of oxidation or burning of the substance as a whole.

Slow oxidation at ordinary temperatures gives rise to spontaneous combustion and deterioration in storage; rapid oxidation has much to do with the initiation and propagation of coal-dust explosions in mines, and with the relative ease of ignition of fuels in general. The process of igniting a combustible substance is not as simple as it may seem on first thought, and just why some fuels ignite more easily than others requires careful analysis.

At temperatures above that of the first appreciable decomposition of the substance (say 250-300 deg. Cent. in case of coal), the process of combustion is complicated by the distillation of combustible gases and vapors and the alteration of the solid material. The gases and vapors of decomposition are not, however, all combustible, and in fact, those produced from the most readily ignited materials, such as wood, are largely non-combustible. A splinter of wood held in a flame ignites quickly, it is true, because the gases of decomposition are heated to their ignition temperatures quickly. But we can also ignite the wood easily in a glass tube at 250 deg. Cent. by passing a current of oxygen over it. Here the ignition cannot be a matter of distilled gases since the temperature used is much below the ignition points of those gases.

Relative ease of ignition is unquestionably dependent to some extent on ease of oxidation, i. e., the rapidity of the reaction of the substance with oxygen. Recent laboratory studies have shown a wide variation among different coals and other combustible substances in their rates of oxidation, and the variation in this property follows the known variation in ease of ignition, in susceptibility to spontaneous combustion, and in rate of deterioration in storage.

The action of oxygen on coal at ordinary temperatures has been shown by recent investigation to consist not in a burning of the carbon to CO_2 nor probably of a burning of the hydrogen to water, but largely of an addition of oxygen to the coal substance. This action develops heat. English investigators have shown that the calorific effect of this oxidizing action at 40 deg. Cent. amounts to between 2 and 3 calories per cubic centimeter of oxygen consumed—only a little less than that produced per cubic centimeter of oxygen when coal is completely burned (3.0 to 3.5 calories). The rate of oxidation increases rapidly with rise of temperature. A coal which at 30 deg. Cent. consumes 10 cubic centimeters of oxygen per 100 grammes in an hour, multiplies this rate so rapidly from the effect of its own production of heat that the temperature would rise to 180 deg. Cent. in a little over two days if no heat were lost. This would result speedily in ignition if an adequate oxygen supply were at hand.

Spontaneous combustion in stored coal results from this slow oxidation by the air at ordinary temperatures. It is not, in any important degree, a matter of bacterial action, or fermentation. When conditions as to the size of coal and manner of piling are such that the rate of heat produced by oxidation is greater than the rate of heat loss by convection currents and radiation, the temperature rises. One of the most important practical considerations is whether an adequate air supply can penetrate to an inner section of the pile where the heat loss is slow. Fine slack coal does not heat seriously in the interior of a pile, if no lump is present. If, however, the interior of a pile consist largely of fine coal and the outer and lower sections consist of lump with very little fine, one of the worst possible conditions is maintained, and spontaneous fires commonly result therefrom.

Deterioration of coal in storage is due to slow oxidation, not to loss of volatile matter. The deterioration in heating value is not as great as has been commonly supposed. With high-grade bituminous and semi-bituminous coals, careful determination has recently shown that this loss amounts to less than 1 per cent in 1 year's exposure to the weather, and less than 3 per cent in 5 years. With our middle-western and western coals or lignites the loss is greater but probably does not exceed 4 or 5 per cent in 1 year in any case. Deterioration in size or physical character may be somewhat more serious, and spontaneous heating even though moderate in degree causes very serious loss. Deterioration of any kind may be quite largely prevented by submergence storage under water.

Much more might be said of the new knowledge of coal, if time permitted; of the different ways in which water is held in the coal substance, of occluded gases, of the fusibility or softening of the mineral constituents at high temperatures, of the forms in which nitrogen and sulphur are combined in the coal and how they behave on heating, etc.

From what has been told, however, it is hoped that some understanding may have been given of the importance of scientific knowledge of coal and its behavior and of the practical bearing of this knowledge on every-day industrial problems.

Bread from Stones

A CIRCULAR entitled "Bread From Stones," written by Dr. C. G. Hopkins of the Illinois Experiment Station, has become an agricultural classic. It is now in its third edition and nearly 100,000 copies have been distributed into all parts of the United States. The circular tells the story of Dr. Hopkins's success in bringing back economically a wornout farm in southern Illinois to profitable production.

The farm under consideration consisted of about 300 acres of poor gray prairie land and was purchased in November, 1903, for less than \$20 an acre. It was known in the community as the "Poorland Farm," and Dr. Hopkins adopted that name for his farm. The work of restoration was begun at first on only 40 acres of the farm. This particular 40 was bought at \$15 an acre. It had been agriculturally abandoned for five years prior to this purchase. It was covered with a growth of red sorrel, poverty grass, and weeds. The land was sour, dead, and depleted of plant food. During the ten years following the purchase of the farm, the 40 acres received the following treatment:

1903—Fall: Purchased, \$15 per acre.

1903—Fall: Applied one ton per acre fine ground rock phosphate.

1903—Fall: Plowed all above under for corn for next year.

1904—Spring and summer: Corn crop.

1904—Fall: Applied limestone, two tons per acre.

1905—Spring: Soy beans.

1905—Fall: Wheat.

1906—Spring: Clover sowed in wheat.

1907—Spring: Timothy and more clover.

1908 and 1909—Meadow and pasture.

1909—Fall: Applied rock phosphate.

1909—Fall: Plowed down for corn.

1910—Spring and summer: Corn crop.

1911—Spring: Oats; volunteer clover appeared.

1912—Spring and summer: Clover harvested.

1912—Fall: Plowed for wheat.

1912—Fall: Applied limestone, two tons per acre.

1913—Summer: Wheat harvested.

Note—Applied six loads per acre of barnyard manure once during the ten years.

Only 39 acres were in wheat, a lane having been fenced off on one side of the field. The yields were as follows:

One and one half acres with farm manure only—11½ bushels per acre.

One and one half acres with farm manure and one application of ground limestone—15 bushels per acre.

Thirty-six acres, with farm manure, two applications of ground limestone, and two of fine ground phosphate in the rotation as described—35½ bushels per acre.

Here we have a yield of wheat about double the average land of the State. The practical farmer will naturally ask, "What did all this cost?" The average annual cost for the purchase, delivery, and application of the limestone and phosphate was \$1.75 per acre. In the ten years, then, the total cost was \$17.50 per acre. Add to this the original cost, \$15 per acre, making \$32.50, and still you have pretty cheap land to produce double the average of the State. Dr. Hopkins puts it this way: "The average annual investment of \$1.75 resulted in the increase of 24 bushels of wheat (35½—11½) per acre in 1913. Thus we may say that the previous application of these two natural rocks, or stones, brought about the production in 1913 of 864 bushels of wheat, an amount sufficient to furnish a year's supply of bread for more than a hundred people."

This story of the "Poorland Farm" is a remarkable instance of the conservation of one of our greatest resources, the soil. Conservation means a saving of the resource by a wise use of it. At the end of ten years of use the soil on the "Poorland Farm" is producing more wheat than the average production of the State, and at the same time its fertility is increasing year by year.—*School Science and Mathematics.*

NEW BOOKS, ETC.

The Individual Delinquent. A Text-book of Diagnosis and Prognosis for All Concerned in Understanding Offenders. By William Healy, A.B., M.D., Director of the Psychopathic Institute, Juvenile Court, Chicago; Associate Professor Mental and Nervous Diseases, Chicago Polyclinic. Boston: Little Brown & Co., 1915.

Dr. Healy has been concerned chiefly with discovering the causes of criminality. The purpose of the investigation is not new, but its methods and its results are strikingly new. Every boy is a potential criminal. A mere accident (the death of a parent, poor school associations, sudden poverty) may change his whole career. Healy finds that the problem of crime always harks back to parental guardianship. Parents must be educated as well as their boys and girls. He finds that practically all confirmed criminals began their careers in childhood or early youth. The determinants of delinquent careers are the conditions of youth. Therefore a knowledge of developmental conditions is important. Data about family traits, early characteristics and environments may be worth much in explaining the offender's tendency. Because the best rewards from scientific efforts are to be obtained from working with youth, Healy has confined himself very largely to boys and girls.

Healy starts from no criminological theory, but obtains all the available facts by a combination of the best methods. His introduction of psychological tests is as new as is his application of analytic methods to throw light on covert mental mechanisms and the startling effects, unsuspected or apparently unrelated, of early experience. Very interesting and dramatic concrete examples showing how boys become criminals are cited. Healy is primarily a student of human character, dealing with motives and driving forces of human conduct. Since conduct is a direct product of mental life, he delves into the mind of a boy, reveals its mechanism, discovers why it is functioning in the wrong way and makes the necessary repairs, so to speak. Often the repairs cannot be made because the criminality is due to hereditary forces over which science has no control.

Healy's work vitally affects parents, ministers, teachers and advisers of boys in general. He points out where they are wrong, where they must reform their methods. Incompetent parental control is a cause of delinquency; so are parental immorality, neglect, lack of comprehension, severity, alcoholism, and vice generally.

Apart from its influence on education, Healy's work is of distinct scientific value because it will enable us to frame more rational legislation for dealing with criminals. Society frames laws for the purpose of making the punishment fit the crime, not the individual. Human wickedness is measured by the degree of violence used or the amount of property stolen. Because we consider the crime rather than the criminal, the whole system of penology and the reformation of criminals is ineffective.

Legislators have never framed laws on a basis of scientific fact, partly because such a basis has been lacking. The law's test of criminal responsibility is wrong from every standpoint—wrong from the standpoint of society and wrong from the standpoint of the criminal. Or as one unjailed expert criminal once told Healy: "The only way to stop us is to find out who and what we are and what we are good for. Then you've got to make punishment severe enough or opportunity good enough for us. You don't do either of these now."

There is a great literature of criminology, but nothing directly helpful to those who must deal practically with offenders. Healy has made the first systematic attempt in this country to gather the scientific facts which should form the basis of all legislation affecting criminals. He concerns himself only with workable methods and the possibilities of diagnosis in cases of delinquency. He is absolutely independent of European teachings—notably the now abandoned Lombroso teachings. He has begun what may well be called a new epoch in rational practical criminology. Healy believes in punishment because criminals believe in it themselves, but the punishment must not harm the offender—must not render him socially unfit. He believes more in an honest and studious attempt at interpretation of criminal delinquency, in reorganizing the courts for better treatment, in treating the physical and mental causes of crime, in changing the environment when necessary, and above all in honest inquiry. No court machinery, he maintains, can ever take the place of deep humanistic understanding. He indorses the statement of a girl who blurted out to a judge:

"You and your officers are here to do your duty, and I suppose you are going to send me away, but before I go I want to tell you one thing: You don't at all understand me."

How many parents really understand their children?

The Spell of Spain. By Keith Clark. Boston: The Page Company, 1915. 8vo.; 439 pp.; illustrated. Price, $2.50 net.

Such names as the Alhambra, Cadiz, and Seville are alone sufficient to prepare us for an Arabian nights entertainment. Mr. Clark and his Doña approach Spain by way of Arabia, in "the high Moorish fashion of Tarik." It is a quiet triumphant invasion. Out of antiquity emerges the shining present—white houses washed by rosy beams, clambering their terraced heights from blue sea to bluer sky. Thus Cadiz. Very charmingly the pilgrimagé leads us along the Spanish roads, over old Moorish bridges, on to the fretted Alhambra. Granada and Andalusia contribute their exquisite plaques to the mosaic of stories charm. It is a pilgrimage the lover of old world life should surely take, in the flesh, if possible; if not, then by proxy. And we can wish him no better guide than Mr. Clark, and no more happy means of conveyance than his easy narration.

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